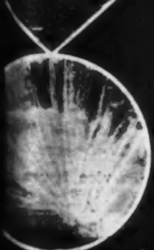
CHEMISTRY



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The Literature of Science

➤ ONE OF THE biggest tasks facing the scientific world is finding out what has already been done on any given problem. Then the time of the researcher may be employed in getting on with necessary new experiments instead of unwittingly repeating old mistakes because he didn't know somebody else had already made them. An even sadder case is that of the worker who makes an original discovery, only to learn that it had been done before and is fully reported in literature that the later researcher didn't take the trouble to look up.

The layman sometimes has the idea that the progress of science is like that of a bowling ball through a set-up of duck-pins, knocking all previously arranged theories galley-west. Reality is very different. Every true advance in science contributes to a more complete sense of order and symmetry among known facts. If an older concept has to be scrapped its removal only opens a wider vista toward a further goal.

It is for this reason that the more light the worker can get on his problem from other minds that have worked on it, the better able he is to tackle the angle of it that he is in position to investigate. So sparsely scattered are such workers through space and time that a considerable search for them is often needed. Sometimes it is so difficult to make that the researcher becomes discouraged from even attempting it.

This should not serve as an excuse for not looking up the subject in the reference services available, especially in the field of chemistry, where the facilities of Chemical Abstracts are so excellent. Through disinterested study of the needs of those who have to use the literature, the problems of making it available for their use will have to be met. The American Chemical Society through its Chemical Literature Section has a committee which is doing outstanding work on this important phase of chemical progress.

CHEMISTRY

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Including The Science Leaflet

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Editors: WATSON DAVIS and HELEN MILES DAVIS

Consulting Editor: PAULINE BEERY MACK (Editor 1927-1944)

➤ Dr. *Lloyd H. Beck and Prof. Walter R. Miles show the National Academy of Sciences a lump of thallium bromo-iodide. This material transmits infrared radiation, and is used in their experiments on perception of odor.*

New Theory of Odor

by Marjorie Van de Water

➤ The perfume of new-mown hay, the fresh tang of the air after a thunderstorm, the disgusting smell of a passing garbage truck—these have been mysteries of science.

How does your nose know? How does your brain get its signals of sweetness or foulness of smell? This is something that wise men and philosophers have struggled with and argued about through the ages.

Newton with his glass prism solved the mystery of the constitution of light. A beam of pure white light was spread into the rainbow of the spectrum. Absorb all but one frequency band of the vibrations called light and you have left a colored light, signaling

in brilliance its part of the whole complete whiteness.

And now a couple of hundred years later odor yields up its secrets. Odor, all the olfactory world, is proved to have its spectrum, its rainbow, its absorption and its fundamental dependence upon solid physical phenomena.

The Newtons of odor are two psychologists from Yale University, who have gone to the bees and the cockroaches for their fundamental knowledge. Dr. Walter R. Miles and Dr. Lloyd H. Beck are experimental psychologists who have found that your nose can smell, just as your eyes can see, because of radiant energy.

The process, however, is in reverse. You see because light energy given off by the sun reaches your eyes. You have a sense of smell, on the contrary, because radiant energy is given off by the smell organ in your nose and is absorbed by the vapors of fresh-pressed cider, the pine woods, roasting coffee, decaying fish, or any other odorous substances.

Just as Newton had his Galileo, so Dr. Beck built his scientific theory of the sense of smell on the sound basis of earlier work in the field. Faraday and Tyndale had studied—but only as a matter of incidental interest—the total infrared absorption of a few odorous substances. Ramsay advanced a theory of molecular vibration as accounting for odors. But these scientists assumed, as did Fabre, Ogle and others, that it is the odorous material that gives out the radiation. Although several radiation theories had been proposed, they had only arbitrary reasons for emphasizing regions of the extensive electromagnetic spectrum; Heyninx chose the ultraviolet, Ramsay the far infrared, Dyson the Raman shifts. But the difficulty with all these ideas is that the human body is a good radiator in only one region of the spectrum—that from eight to 14 microns. There it is excellent.

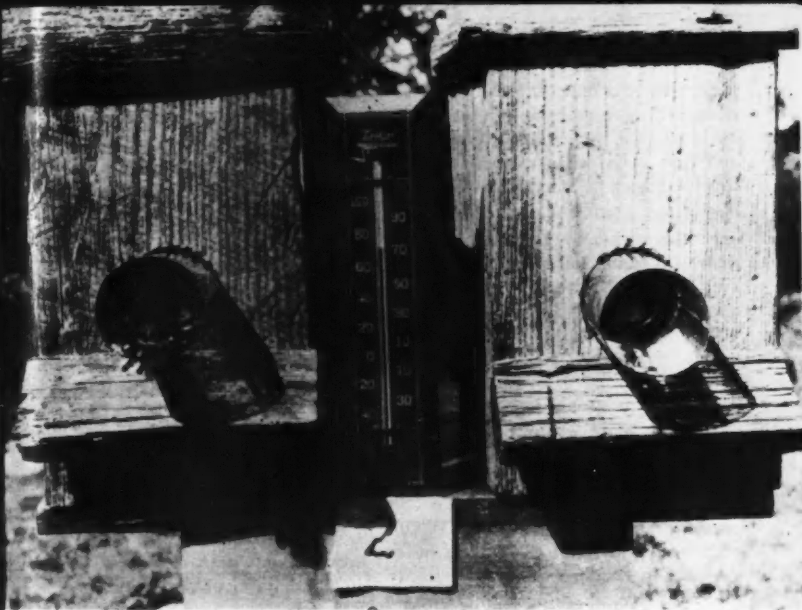
Dr. Beck reasoned that it is the nose that gives off the radiation and the odorous substance that picks it up, and that it is the 8-14 band that is important. Then he and Dr. Miles set up experiments to test this revolutionary idea.

The tiny receptors in your nose that enable you to smell are hair-like antenna that broadcast infrared radiation—heat waves. The wavelengths, like the antenna that send them out, range from something like eight microns to 14 microns in size. That is, the largest are only about half the size of the finest hair on a blonde's head.

Fitting in with Dr. Beck's theory are the many facts that are known about the physics and chemistry of odorous substances.

Oxygen, the gas that you inhale with every breath because it is so plentiful in the air, is odorless. Why? Because, although it reaches your nose in abundance, it cannot pick up rays of the special smell wavelength. On the other hand, another form of oxygen, ozone (O_3), does absorb them. Ozone has that refreshing odor that you notice in the air after a thundershower or around an ultraviolet light.

Evil-smelling rotten eggs are within the smell band and so also are the ether that you smell around hospitals or biology laboratories and hydrocyanic acid which has the odor of a peach kernel.



➤ HONEY *is behind the window in each of the boxes. Windows are made of thallium bromo-iodide, which allows infra-red radiation to pass through. The window on the right is covered with a pane of glass as well, which cuts off the infra-red. Bees desert it, but cluster around the left-hand box, where they detect the honey.*

Dr. Beck and Dr. Miles are now working on the preparation of a "rainbow" of smell—the infrared absorption bands for various odors. From the preliminary work already done on this, Dr. Beck believes that they will find that the perfumes and pleasant odors are grouped in the middle of the smell rainbow in a region comparable to that of yellow on the color rainbow. At the short end, where the blues and violets are in color, he expects to find the acid smells. Among the longer wavelengths, the "red" end, will probably be grouped those disagreeable odors known scientifically as "goat-like."

There is, Dr. Miles explained, a "white smell" comparable to "white light," which is a combination of all colors and therefore affects all the vision sense cells. "White smell" is that burnt or "fresh" smell that you notice occasionally when sniffing very cold air outdoors in winter. It doesn't smell anything like that other burnt smell of a candle or of sooty air.

Dr. Beck's theory would also ex-

plain why it is that the fresh perfume of a garden in springtime is so different from the stench of a battlefield and how it is possible to detect the subtle difference in scent between one flower and another.

If the bundles of antennae that make up your sense organ of smell are each of a different size and shape and each broadcasting on a distinctive wavelength, then each different odor might bring into action a separate antenna or group of them, giving the brain its own special signal.

As your nose gives off radiation, Dr. Beck reasoned, your brain senses the sudden loss of heat energy and as the heat is lost, the nose keeps on putting out more and more. What your brain really notes, then, is heat loss of a particular wavelength from the smell receptors. But that sensation may be interpreted directly as the fragrance of your best girl's favorite perfume or the appetizing odor of broiling beefsteak.

This is comparable to the way you feel cold. If you put your hand on a cake of ice, of course it feels cold. But the ice is not giving off cold. What actually happens is that the ice absorbs the heat being radiated by your hand. You feel this quick loss of heat from your hand through certain nerve endings in the skin, and your brain interprets this as "cold" in the ice.

If the loss of heat is not from your hand but from the tiny hair-like organs of smell in your head, your brain telegraphs "perfume" instead of "cold."

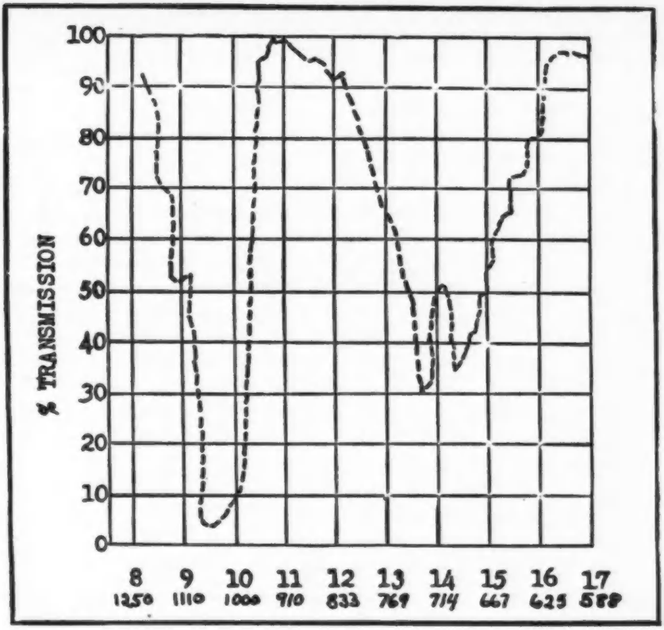
Now scientists have a better explanation of why you can smell some things and why others appear odorless. They have ways of explaining, too, why the same material may seem spicy or fragrant at one time and flat or odorless at another.

In the first place, the material smelled must be colder than your nose. Remember the delightful perfume that assails your nostrils when a florist opens the door of his refrigerator? Remember how sweet your garden is in the early morning while the dew is on the flowers or in the evening when the earth is cooling off? The moisture of the dew is cooling and accents the flowers' perfume by absorbing more of the radiation from your nose.

Incidentally, your nose itself helps to cool the air that carries the perfume to your nostrils. Even if it is hot when it enters your nose, it cools in passing up the column of air inside.

Under what circumstances can you smell an ordinarily odorless substance? This is a scientific riddle for which Dr. Beck is predicting that they will find the answer. Cold hydrogen, he thinks, when blasted up the nose should smell strongly burnt. He is also searching for an answer to the question as to whether chemical compounds differing only in constituent isotopes have the same odor. Is heavy methane, for example, as odorless as ordinary methane?

A dog's nose is better than a human nose for smelling, these psychologists explain, for several reasons. In the first place, it is cold at the tip. Then, too, it is moist, and the evaporation of the moisture serves to cool the odorous substance as it passes through the dog's nostrils. Finally, the cavity containing the odor sense cells of the dog is larger. This means that the amount



➤ TROUGHS *in this curve show absorption of infra-red radiation by ozone (O_3) in the range of wave-lengths believed responsible for odors. Oxygen (O_2), which is odorless, does not have absorption bands in this region.*

of odor material required is less than for man.

Until this theory was announced to scientists at the meeting of the National Academy of Sciences in Washington, there was no good way to describe an odor accurately in physical terms. You can say that a geranium smells more like a marigold than like a violet, but no one could ever identify a geranium just from that description, and there might be a lot of disagreement with it by those who know the smell of that flower.

Now it may be possible to describe odors in terms of infrared wavelengths and arrange typical odors on a scale. Chemists may be able to learn how to compound substances less empirically so as to have a desired odor made to order, or may be enabled more directly to eliminate odor from a material entirely merely by combining it with another substance that would change the absorption band. Such a psycho-physical scale may make Galton's dream of a "smell arithmetic" come true.

The scientists do not yet know whether the blending of odors is comparable to the mixing of colors or is more like the combining of sounds. When you mix red and green lights together, you produce a yellow color which even an expert cannot distinguish from ordinary yellow. But when you play a chord on the piano, the musician can pick out the individual notes from which the combined sound is made. In the Yale psychology laboratories, research is now going on in this field. Preliminary evidence from the experience of expert perfume chemists indicates that the mixing will be more like sound combination than color mixing.

Dr. Miles and Dr. Beck tested their theory with insects. These little creatures fortunately wear their smelling apparatus on the outside in their long, waving antennae. Thus, they are smellers as much as "feelers," and when they note an odor they wave their antennae as if they were excited. This makes it possible for the psychologist to watch and even measure roughly their response to various odors.

One group of experiments was made on bees. They were first attracted to the location of the experiment by a dish of honey. This was just to be sure that the bees had an interest in what was going on. Then the dish was removed and the experiment started. More honey had been placed in the bottom of two iron boxes and sealed in tight. But each box had a tightly closed window made of thallium bromo-iodide, a heavy material of a beautiful red color made by the Army especiallv as a filter to pass infrared radiation. The two windows looked exactly alike from the outside, but behind one of them was a pane of ordinary glass that cuts off completely the infrared rays involved in smell.

Now the question was, would the bees still smell the honey inside the box in spite of the fact that no chemical vapor or gas could possibly escape from the box? Apparently they did, for soon they were nearly all clustered around the window that let the infrared rays through and only a few if any remained on the window that cut off the radiation. Up to ten times as many preferred the infrared passing window. In each of the iron boxes, the air and the gas from the honey were cooled so that radiation from the bees might more readily enter.

In another experiment roaches in a wire cage, at each end of which were airtight jars equipped with windows made of infrared-passing potassium bromide crystal, responded to oil of cloves.

Other experiments are now in progress on man and lower animals.

Dr. Beck and Dr. Miles are further advancing this research by the delicate under-the-miscroscope job of recording the electrical impulses in an insect's antenna to find out more about how smell takes place. As this whole program of research progresses, our world of perfumes may be revolutionized. Pleasant scents may be tailor-made to produce desired emotional effects in theaters, stores and other public places. Unpleasant odors can more easily and scientifically be eliminated or altered in rubber goods, varnishes, glues, inks, laundry soaps, and so on.

Four Waves of Advance
In Understanding the Atom

The Structure of the Atom

Professor of Physics, Princeton University. An address delivered at the Cooper Union Forum.

by John A. Wheeler

▸ If science can be called the human activity concerned with extending the range of our experience and reducing this experience to order then the study of the atom is science indeed. Nowhere, except perhaps in astronomy, has man gone further in exploring, by the aid of ingenious experiments, a domain of distances entirely outside the realm where he lives and moves, and nowhere has a logical structure more harmonious and beautiful been erected to bring into order the great range of experience so uncovered.

The science of the atom has advanced in three great waves and we are now in the midst of a fourth wave whose outcome we cannot predict. First was the period of the last century when evidence from chemistry, evidence about pressure and temperature relations of gases, evidence about the effect of electric currents on solutions, all forced the recognition of the existence of molecules and atoms. At the end of the first period the 92 atoms formed the starting point for any description of nature and these atoms were themselves regarded as elementary units. The second period of advance extended from 1911 to 1928 and lead to the view that the atom itself is a complex system composed of a central nucleus and planetary electrons circulating about it. At the end of this period it proved possible to summarize in a few simple principles the laws of motion of these electrons and with the aid of these laws to give a satisfactory account of a most extensive range of physical experience.

The quantum theory of the atom accounted for the characteristic colors given off by the individual chemical elements in an electrical discharge and the chemical affinities of certain atoms for certain other atoms for the stability of molecules, for the melting and boiling points of fluids and liquids, for the existence of metals and their electrical conductivity, and in fact, so far as mathematical difficulties did not supervene, for all the physical properties of ordinary matter as we know it. At the end of this second period we recognized all atoms as systems of the same kind built up out of a fundamental unit, the electron, together with an exceedingly small nucleus. Only the electric charge on the nucleus had any significant effect on the properties of the atom, and the electric attraction of the nucleus determined how many electrons went in planetary orbits about it.

The third great period of advance extended from the discovery of the neutron by Chadwick in 1933 to the elucidation of the phenomenon of fission of uranium in 1939. This period of advance began by recognizing as common building blocks of all nuclei, the newly discovered neutrons

and the protons which occur in free form as nuclei of hydrogen atoms. To these two particles was given the common name of nucleon and to the science of their combination in stable arrangements and their rearrangement in collisions has been given the name of nucleonics. The explanation of the radioactivity of radium, the operation of a chain reacting pile and the explosion of an atomic bomb all form part of this science of nucleonics. This science is now comparable in its unity and comprehensiveness with the science of chemistry itself. Just as chemistry can predict, from the science of atomic structure, the energy which will be liberated when atoms combine to form molecules, so nucleonics can predict with a reasonable accuracy from the science of nuclear structure how much energy will be released by neutrons and protons in any given proportions combined to form a nucleus of any given size. As important as the energy of a reaction is the probability it will take place. The rate of a reaction is no more important in chemistry than it is in nucleonics. In this science the likelihood that a bombardment of nucleus (b) by nucleus (a) will give rise to any chosen product is measured by an effective target area or cross section. A few simple principles suffice to predict these cross sections in a large number of cases of practical importance. These principles make it possible to see why it is very unlikely that any nuclear chain reaction can be developed on the earth which does not make use of neutrons and nuclear fission. The same principles make it possible to see why in stars, under conditions of very high temperature, energy producing reactions take place which can be produced on earth only under laboratory conditions.

It was an amazing feature of the second and third periods of advance that the idea and problems of structure could be separated so cleanly from each other and that they yet had such a striking similarity. The nucleus looks to an electron one hundred times smaller than the sun looks to the earth and its internal structure is of even less importance to the earth than internal construction of the sun is to the earth in its orbit. Conversely, the motion of the neutrons and protons within the nucleus is affected to no noticeable extent by the motion of the planetary electrons in their far away orbits. Yet both the properties of the atomic system and the properties of the nucleus found their explanation in terms of one or two elementary particles. All of chemistry, all of the structure of the atom outside the nucleus, all of nucleonic physics itself required for their explanation only three particles: the electron, the proton, and the neutron.

Intermediate Particles

We are now in the midst of a fourth period of advance where we recognize not only that the neutrons and protons themselves are probably not elementary particles in the same sense as the electron, but also where we are finding an increasing number of new particles which are intermediate in mass between the electron and the eighteen hundred times heavier nucleons and which do not fit in any now recognized way into our description of nature. In contrast to atomic physics and nucleonic physics the science of these new particles,

their creation, their destruction and their transformations and relations to each other is sometimes called sub-nucleonic physics and sometimes elementary particle physics. The first one to make a clean division between nucleonic and sub-nucleonic physics was Heisenberg. It was he who in 1933 essentialy proposed to exclude from the science of nucleonic physics those transformations in which electrons were observed to come out of atomic nuclei. He noted that a nucleus composed solely of neutrons and protons which forever preserved their character could never give out an electron. He therefore proposed to say that the process of emission of an electron from the nucleus was a process in which one of the neutrons transformed into a proton and an electron. The problem of such changes is evidently one of sub-nucleonic physics. Other elementary particle transformations had been discovered the year before, in September 1932, by Anderson. He found a beam of electromagnetic radiation was able to create a pair of negative and positive electrons in the free space outside the atomic nucleus. Later observations showed that the positive electrons so observed were capable of annihilating the ordinary negatively charged electrons with the complete conversion of their mass into electromagnetic energy. In 1938 Anderson and Nedermeyer, in the course of studies of cosmic ray particles, found evidence for a new particle, now called a meson, with a mass two hundred times as great as the mass of an electron or one-ninth as great as the mass of a proton or neutron. This past summer Powell has found evidence of still another kind of meson with mass about twice as great as that of Anderson's meson. A few years before Leprince Ringuet had found one picture of a particle with a mass nine hundred times the mass of an electron. A communication which has just been sent to press and which has not appeared yet in print by Rochester and Butler of the University of Manchester reports more evidence for a particle of mass about 900. Evidently the scheme of things is much more complicated or much simpler than we at first conceived. More and more the possibility suggests itself to us that all the heavier particles are built up, in some way we do not now understand, out of positive and negative electrons. Moreover, a re-examination of older arguments that there can be no electrons in the nucleus leads to the conclusion that it has in fact no physical meaning to say that there are no electrons in such small domains. Any physical experiment designed to measure the number of electrons in the nucleus will automatically cause the creation of an indeterminate number of pairs of negative and positive electrons which will be indistinguishable from the electrons which one seeks to observe. The remarkable behavior of positive and negative electrons in domains as small as those of the nucleus lends a special interest to this branch of elementary particle physics and suggests that there may be hope in this direction to gain some insight into the structure of the other elementary particles.

Mesons in Orbits

Recent experimental and theoretical studies of the interaction of negatively

charged mesons with atomic nuclei furnish another point of advance on the elementary particle problem. Such mesons are able to move in orbits around the atomic nucleus which resemble the orbits of electrons in shape but are in size two hundred times smaller. Simple arguments about the energy released in the jumps of negative mesons from one of these orbits to another leads one to expect that these particles will be able to initiate a special type of fission in uranium or heavier nuclei. Although experiments in this direction have not yet been performed, the theoretical evidence leads one to believe that in such a reaction the energy release will be about three hundred million electron volts — about 50 per cent more than the energy released in the usual type of fission process.

Titanium Joins Light Metals

➤ ANOTHER LIGHT METAL, titanium, may soon join aluminum and magnesium in the construction field. The principal present use of this abundant, but little known, metal is as a chemical compound, a white pigment in white paint.

Now, because of an improved process of reduction of its ore, it will be available for use as a pure metal in machinery and in structures.

Until about 1900, practically no pure titanium had ever been made except in laboratory experiments. Since then, several methods for reducing the ore have been developed, but none entirely satisfactory for commercial production. By a modification of some of these methods the U. S. Bureau of Mines has developed a process that promises to make the metal relatively plentiful.

A pilot plant of the Bureau is making 100 pounds a week. A commercial plant, with improved engineering, can produce far greater quantities.

The process used by the Bureau of Mines consists of reducing titanium tetrachloride with pure molten magnesium in the presence of helium gas under pressure. This non-combustible gas prevents oxidation in the process.

Titanium is the ninth most abundant chemical element in the world, and is exceeded only by iron, aluminum and magnesium in metals suitable for engineering purposes. It is widely scattered throughout the world, including America, usually in two minerals known as rutile and ilmenite. Commercial production of titanium compounds is usually from beach-sands.

The paint pigment is titanium oxide, known to painters as titanium white. It is used to supplement or replace zinc oxide and white lead, two of the more common constituents of paint. Titanium is used also in steel alloys to impart toughness and shock-resistance. In its pure form it is suitable for use for many types of construction, including machine parts.

In weight, titanium is about twice as heavy as magnesium, considerably heavier than aluminum, but still much lighter than steel. It is described by the Bureau as a light, corrosion-resistant metal that combines the properties of stainless steel with those of strong aluminum alloys.

Atomic Bomb Poisons Body's Blood Factory

Radioactivity Damages Marrow

THE DEBRIS from atomic bombs contains the world's most dangerous radioactive agents which can fatally bombard the body's bone marrow where blood is made.

This was discovered in a University of California research that had as its object finding what biological action can be expected from the elements born of atomic fission and of the atomic piles.

The findings are significant primarily for two reasons: 1. They have helped make the nation's atomic production plants and experimental laboratories among the safest there are; 2. They elaborated the implications of the possible biological action of atomic explosions or use of by-products of the atomic piles as a sort of atomic poison gas in warfare.

In a comprehensive report issued under the sponsorship of the Atomic Energy Commission and with acknowledgment to the Manhattan Engineer District, Dr. Joseph G. Hamilton, University of California medical physicist, describes in the *American Journal of Radiology* animal research which has been in progress in Berkeley since 1942 on the metabolism of the fission products and of the trans-uranic elements.

In a description of the scope of the problem which confronted scientists when they undertook to develop an atomic energy industry, Dr. Hamilton made a comparison with radium. He pointed out that since radium was discovered 50 years ago, one kilogram, or a thousand curies in terms of its radioactivity measurement, has been isolated.

During these 50 years a large number of instances of radium poisoning have occurred, Dr. Hamilton pointed out.

He added that the fission products alone produced in the Hanford atomic piles are in the range of millions of curies, and that kilogram quantities of plutonium have been isolated by complicated chemical processes involving many workers.

Since the trans-uranic elements and the fission products, including nearly 200 isotopes of 34 elements extending from zinc to europium, are with one or two exceptions strange to the human body or undetectable if present, and consequently nothing was known about their biological effect in 1942, the magnitude of the problem was readily apparent.

Dr. Hamilton and his co-workers have studied the distribution, retention and excretion in the animal body of 20 of these radioelements, and are continuing research on others.

Included are five elements which are synthetic products of the atomic ovens or of cyclotron bombardments, which are not found in nature. These are element 61, and the trans-uranic elements plutonium, neptunium, americium and curium. So rare is

curium in the world that its metabolism was studied with quantities too small to be visible to the naked eye; only in the last few weeks has a grain-sized quantity of this element been isolated in pure form in the Berkeley laboratories.

The Berkeley scientists duplicated as nearly as possible the manner in which poisoning from the radioelements might occur, through the mouth, nose and scratches or cuts in the skin.

Slices of bone or tissue were then placed on a photographic plate, the radiations from the deposited elements exposing the plate and giving a picture of the distribution of the materials.

Dr. Hamilton said the most significant finding was that many of the highly radioactive groups of elements studied are deposited in a thin layer of tissue, the osteoid matrix, adjacent to the bone-marrow cavity.

The bone marrow manufactures red blood cells, and is extremely sensitive to radioactivity. Its bombardment by alpha particles emitted by some of the elements could interfere seriously with the multiplication of red blood cells and white corpuscles, the scientists found. Further, the body does not eliminate these elements readily, and they remain radioactive for a long time.

Plutonium, neptunium, americium, curium, and the naturally occurring element, thorium, are included in this group, as well as the fission products, yttrium, zirconium and cerium. Dr. Hamilton said it is probable that others would have a similar action in the bone, including the fission product isotopes of columbium, lanthanum, praseodymium, neodymium, element 61, samarium, europium; and the naturally occurring forms of the elements actinium and proactinium.

Some of the fission products are slightly less dangerous because they emit lighter beta particles, Dr. Hamilton said. But the actinide series, including plutonium, have the undesirable characteristics of radium in that they have long half-lives and emit heavier alpha particles.

Dr. Hamilton said that radium is probably less dangerous, for comparable amounts of radioactivity, than, for example, plutonium. The reason is that radium is distributed throughout the mineral structure of the skeleton with the result that fewer alpha particles penetrate to the marrow.

The research was done in collaboration with Dr. Robert S. Stone, professor of radiology in the University of California Medical School, formerly head of the plutonium project health organization, by Dorothy Axelrod, Josephine Crowly, Dr. Harvey Fisher, Henry Lanz, Kenneth G. Scott, Dr. L. Van Middlesworth, Dr. D. H. Copp, Dr. I. L. Chaikoff, Dr. D. M. Greenberg, Dr. Roy Overstreet, Dr. Louis Jacobson, and Dr. Hamilton.

On the Back Cover

➤ Precaution *against danger from radio-active chemicals is emphasized by this periscope view into the closed chamber where experiments with fission products are conducted. The photograph is from Monsanto Chemical Co.*

Atomic Power Workers Need Special Protection

Heavy Metals Poisoning

by Jane Stafford

➤ A new, deadly disease of the atomic age was reported to the International Cancer Congress in St. Louis recently. It is named plutonism, for the element, plutonium, discovered in atomic bomb researches.

It has never attacked a human being. It probably never will, because of the care being taken to protect atomic energy workers. But hundreds of mice and rats in the Argonne National Laboratory, Chicago, have died of it. Dr. Herman Lisco and Miriam P. Finkel of that institution reported their studies with this radioactive chemical.

Plutonium gives off all alpha rays. Compared to beta and gamma rays, these alpha rays have not been considered very dangerous. They are big particles, but they can penetrate only through short distances or thicknesses. If they strike the body from outside, they can hardly get through the skin. But within the body, concentrated in one place, they can cause great damage in that area.

This might make plutonium good treatment for cancer by localizing its rays at the site of the cancer. But the element has a half-life of over 20,000 years, which makes it too dangerous to use. The cancer might be destroyed, but the chemical would go on emitting rays which would cause other cancers.

Time as well as the size of the dose of plutonium is important in the damage it does. It takes much longer for radioactive chemicals to cause cancer than for non-radioactive, coal tar chemicals.

A mouse has a short life compared to man. It may die before it gets cancer from radioactive material, but a man lives long enough to get the cancer, Dr. Austin M. Brues of Chicago pointed out. His studies show that it is absolute, not relative, time that is important in the development or cancer from radium or other sources of radiation. This absolute time factor may be important in connection with other causes of human cancer.

Toxicity of Uranium

➤ Uranium poisoning of the kidney is a hazard facing atomic power workers unless suitable precautions are taken.

The chemical toxicity of uranium is a greater danger than the radiation hazard of the element itself before fission. The public has heard little of this chemical hazard but it was given full attention by the group protecting the health of the atom bomb workers, Dr. Andrew H. Dowdy, radiology professor and Manhattan department director at the University of Rochester, reports.

One of their first problems was to devise a reliable method for detecting uranium in very small quantities. One part of uranium in 10,000,000 parts of

animal tissue, blood or urine can be accurately measured by the method they developed, Prof. Dowdy reported to the American Public Health Association. Its presence can be detected in such small amounts as 1/2,000,000,000 of a gram.

The poisonousness of uranium varies to a certain degree, though not entirely, with the solubility of the compounds. These may be found in the form of dusts or gases.

Many of the uranium compounds may be absorbed into the body through the skin, by way of the lungs or from the stomach and intestines by being swallowed.

Protection against uranium poisoning consists in completely closed systems, adequate ventilation systems to evacuate harmful agents from the atmosphere, gas masks, and special procedures for laundering the work clothing of plant personnel.

Personal hygiene and rigid medical supervision to detect small amounts of harmful substances in the excreta of personnel are important for health protection.

In pre-atom bomb days, uranium-damaged kidneys were found capable of repairing themselves in such a way that they could resist repeated further doses of uranium nitrate and also doses of bichloride of mercury. This finding was reported by Prof. William deB. MacNider of the University of North Carolina in 1938.

An immediate cure for cancer from atomic bomb by-products must not be expected, Dr. Dowdy warned. Radioactive phosphorus is potentially useful for treating polycythemia and the leukemias, and radioactive iodine seems promising in treatment of cancers of the thyroid. Cancer of the thyroid, however, is infrequent compared to other kinds of cancer, and only a very small percent of the thyroid cancers respond to radioactive iodine treatment.

The most important and immediate value of atom bomb by-products in medicine, Dr. Dowdy declared, will be their use in investigation of fundamental problems of disease.

Radiation Injury Treatment

➤ Studies of means of treating radiological injury to man is being undertaken by a new atomic radiation medical laboratory which began operations in October at the University of California at Los Angeles.

Dean Stafford L. Warren, of the Medical School on the Los Angeles campus, directs the laboratory which will function under a contract with the Atomic Energy Commission.

Medical data collected after the atomic bombings of Hiroshima and Nagasaki and in the tests at Bikini forms the starting point of the project.

Dr. Warren has been closely associated with medical aspects of the atomic bomb since 1943, when he was appointed medical director of the Manhattan project. Later he was in charge of radiological survey parties studying the Japanese cities. He also headed the medical staff at Bikini in 1946.

Dr. Warren began operations with a staff of from 30 to 40 people, and the research is being closely coordinated with similar work being done on the Berkeley campus of the University.

Atom Bomb Effects on Heredity

➤ THE EFFECTS of radiation from the atomic bomb on Japanese children and their children's children will be investigated in studies under the guidance of American experts including the genetics authority and Nobel Prize winner, Dr. H. J. Muller of the University of Indiana.

The studies are part of a long-range research program undertaken jointly by the Atomic Energy Commssion and the National Research Council.

The effects of atomic radiation on blood cells and on the development of various disease conditions, including the formation of peculiar scar tissue called keloids, are being studied.

Knowledge important for protecting the health of workers in atomic energy production plants and everyone living in the atomic age may come from the studies.

Excellent health safety records have been maintained in the atomic energy industry. And there is no reliable evidence so far on which to base an opinion about the frequency of abnormalities among children born in Hiroshima and Nagasaki since the atomic attacks. But with radioactive substances playing an increasingly important role in everyday life in the United States and perhaps elsewhere, medical authorities believe it important to gain all possible information on the subject.

The long-range research program is a result of a directive issued by President Truman. It is being financed by the Atomic Energy Commission and the scientific program is directed by the National Research Council's committee on atomic casualties. As far as practicable, Japanese scientists will take part in the studies under arrangements with Gen. MacArthur's staff.

Dr. Thomas M. Rivers of the Rockefeller Institute is chairman of the committee on atomic casualties. Other members are: Dr. George W. Beadle, California Institute of Technology; Dr. Detlev W. Bronk, National Research Council; Dr. Austin M. Brues, Argonne National Laboratory; Dr. George M. Lyon, chief of the Radioisotope Research Section, Veterans Administration, Washington, D. C.; Dr. Shields Warren, Harvard Medical School; Dr. Stafford L. Warren, University of California; Dr. George H. Whipple, University of Rochester; Dr. Raymond E. Zirkle, University of Chicago.

The studies in heredity and genetics are under the guidance of Dr. Muller and Drs. C. H. Danforth, Stanford University; D. R. Charles, University of Rochester; L. H. Snyder, Ohio State University; and James V. Neel, University of Michigan, who is in charge of the field studies in Japan.

Diesel engines in various parts of the world are operating satisfactorily on linseed, cottonseed, peanut, tung, palm and camphor oils.

Non-woven fabrics are now produced of plasticized synthetic fibers and natural fibers partially fused together under heat and pressure.

Oil and Gasoline Have Many Possible Sources

Synthetic Hydrocarbons

by P. C. Keith

President, Hydrocarbon Research, Inc., before a Socony-Vacuum Manufacturing Group Meeting.

➤ Carbon monoxide and hydrogen have been the building blocks of a rather special branch of the organic chemicals industry for a long time. The same building blocks are about to create a gigantic synthetic gasoline and diesel oil industry which will have far reaching ramifications.

The evolution of syntheses of this type has progressed from the early work of Sabatier thru that of Fischer and Tropsch to the present status.

Of equal importance was the development of better methods of producing the building blocks from those raw materials which are available in nature in sufficient quantities, and at such production costs, as to make exploitation on a broad scale a sound enterprise.

Natural Gas

Partial and controlled combustion of natural gas with the use of oxygen has been developed to such a point that it has replaced the earlier and more costly "catalytic reforming" method of production. The eventual production of 1 barrel of finished liquid petroleum products requires the gross (fuel plus process) use of 10,000 cu. ft. of natural gas by this method.

The estimated proved reserve of natural gas in the U.S.A. is 160 trillion cubic feet. The reserve has been increasing steadily, since the new discoveries are larger than the current consumption. Assuming half of the reserve available for Hydrocol purpose this represents a potential production of 6.8 billion barrels of gasoline and 1.2 billion barrels of diesel oil.

Heavy Oils

The supply of light crude oils is diminishing — refineries are faced with the necessity of processing crude oils which will steadily get heavier, more devoid of the lighter fractions and with a steadily decreasing hydrogen carbon ratio.

Heavy oils can be converted to carbon monoxide and hydrogen by means of oxygen and steam but a more attractive scheme involves the combined use of gas and heavy crude oils.

Solid Fuels

Coal, tar sands and shale can be used for the production of carbon monoxide and hydrogen. Their use as raw materials will become attractive in the not too distant future. Needless to say, the reserves of these materials extend into hundreds of years.

The Brownsville plant of the Carthage Hydrocol Co. will produce 6500 barrels of gasoline and 1000 barrels of diesel oil from 75,000,000 cubic feet of natural gas containing 5% nitrogen.

The organic chemicals which are produced as by-products will revolutionize the organic chemicals industry.

Auto Engine Compression Varies With Octane Number

We're Both in the Same Boat

by T. A. Boyd

Research Laboratories Division, General Motors Corporation, before a Socony-Vacuum Manufacturing Group Meeting.

▶ The automotive industry in relation to the petroleum industry, in the particular field of gasoline and its utilization, is our general theme. The relationship between our two great industries is not that of second cousins at all. It is a very close one indeed. Our mutual dependence is so great as to make cooperation vital. And fortunately we have been cooperating in essential respects now for 25 years and more.

The ideal automobile gasoline must be plentiful, low in cost, high in energy, easy to vaporize, and free from knock. One of the greatest services of the petroleum industry has been to supply gasoline all these years in such huge amounts that the lack of it has never been any handicap to the usefulness of the motor car. It is recognized that the chief reason why there has never been a shortage lies in technological advances within the industry in means of finding, producing and refining petroleum. So efficiently has that been done that the cost of gasoline today, ex-tax, is just half of what it was 25 years ago. And the same degree of cost reduction has been made to hold true for the motor car also.

In respect to volatility, gasoline has over the years passed through an evolution from high to low and back again to high, with cars meanwhile being adapted to use the gasoline of the time. Today, with the huge demand for gasoline and with the expanded use of catalytic cracking, the higher boiling product of which is good in degree of freedom from knock, there is pressure to use more of the higher boiling fractions and thus to make gasolines somewhat less volatile again. It is natural and right that a proper amount of such higher boiling material should go into automobile gasoline. But there are certain limitations upon how much of that ought to be done. These limitations arise out of such conditions as the following: the importance of rapid warm-up to driver satisfaction, as well as to engine cleanliness and cost of maintenance; the circumstance that constituents which cause varnishing and sludging in engines during certain conditions of operation appear to be concentrated mostly in the higher boiling fractions; and the adverse effect of adding more heat to the mixture upon the knock ratings of fuels, particularly of the sensitive gasolines produced in modern refining processes. For these and other reasons it appears that any decrease in volatility ought to be one of gradual evolution, and that meanwhile the subject should have careful study by our two industries.

The fifth gasoline quality, that of

freedom from knock, is one of the most important of all, for it determines compression ratio and the efficiency with which the fuel can be used in engines. Freedom from knock is a quality in which considerable improvements have already been made and in which there are possibilities of further improvements still.

Recent experiments by the Research Division of General Motors have demonstrated that a high compression engine can be smooth running and that it can give gains of one-third or more in miles per gallon by comparison with a comparable present-day engine of ordinary compression. Because a considerable number of what might be called mechanical octane numbers have been built into that experimental engine in the way of ability to use sensitive fuels, without depreciating them at all, its octane requirement is little if any higher than is represented by fuels which can be produced by practical processes now known. And this is true in the face of the fact that, to demonstrate in thoroughly convincing manner the usefulness and the practicality of high compression, this engine has the very high compression ratio of better than 12 to 1.

It seems natural, therefore, to expect that the compression of automobile engines and the octane number of gasolines are due to rise in the future. The collaboration of both our industries will be of course needed to bring about such a change in any important degree. But the time when use could be made of a higher octane gasoline is right upon us. As a result of extensive experimentations by the engineers of automobile companies in recent months, it is known that higher compression engines can be put into production. The problem of how to bring out gasolines which are enough higher in octane number to make possible the first worthwhile step-up in compression, and to do so on a nationwide basis, is therefore one which deserves, and which is no doubt receiving, the most serious attention of the petroleum refining industry.

Few Organic Chemicals Now Useful

➤ Only three percent of the 300,000 known organic chemicals are currently useful, while the rest await development, Hoyt M. Corley of the chemical research and development department, Armour and Company, estimated recently.

Pointing out that this represents a challenge to chemists, Mr. Corley said that of the 9,000 now useful chemicals, only 5,000 are being manufactured in the United States.

Writing in *Chemical and Engineering News*, the chemist explained that there are three reasons why so many chemicals have not been developed commercially. The three reasons:

1. They have not been properly promoted.
2. Civilization has not progressed sufficiently to use them.
3. Production costs are prohibitive in relation to the functions performed.

Civilization a hundred years from today will require many chemicals now well known but not of commercial importance, Mr. Corley predicted.

For the Home Lab:

Soap Opera

by Burton L. Hawk

Prologue

➤ Many years ago in the ancient land of Gaul, a long-forgotten warrior made a startling discovery. He found that dirt and grease could easily be removed from his hands by washing them with wood ashes, of all things. As time went on, other members of the tribe improved upon this method. Water, wood-ashes and goat's tallow were blended together to form the first soap, which was later prepared and used by the Romans.

And through the years, the art of soap-making has gradually progressed to the highly specialized industry of today.

Our cast of characters consists mainly of alkali, the hero, and fat, the heroine. They are assisted by a supporting cast of alcohol and water. The action takes place in an evaporating dish and in a beaker.

Act I

Place 5 cc. of olive oil in a glass evaporating dish. In another container dissolve 2 grams of sodium hydroxide in a solution of 5 cc. of water and 5 cc. of ethyl alcohol. Add this to the olive oil; stir thoroughly and apply gentle heat. It will be necessary to stir the solution occasionally during heating. Do not heat too strongly.

This reaction of an alkali and a fat is known as *saponification*. It can be compared somewhat analogously to inorganic reactions of bases and metallic salts to form a hydroxide and a salt. Here a fat and an alkali form glycerine and a soap. Most soaps are chemically sodium stearate, sodium palminate, sodium oleate, or a mixture of these salts depending on the type of fats used.

Intermission

The solution should be allowed to boil gently from 10 to 15 minutes or until all oily globules disappear. If necessary more alcohol and water solution may be added.

Act II

Fill a beaker half full of salt solution. Remove the soap solution from the flame and pour into the beaker. Stir rapidly. The soap will be precipitated ("salting-out") and can be obtained by filtration.

Although we have specified olive oil, any fatty oil can be used in making soap. Also lard or any fat may be used. Grandma used to make soap from the fat left over from Sunday roast.

A good soap contains little or no free alkali. No doubt the crude soap prepared here will contain much free alkali, therefore would be harsh to the hands. ("dishpan hands").

Dissolve a small piece of your soap in water and note the fine suds. Prepare a solution of magnesium sulfate and add to the soap solution. Unfortunately the magnesium salts of fatty oils are insoluble in water, thus making soap almost useless in "hard"

waters. Note a white precipitate appears as the suds disappear.

Epilogue

"Whee .. ee .. ee that *sparkle!"* - - - "Ninety-nine and forty-four hundredths per cent pure. It floats!" - - - "happy little washday song!" - - - " - - - does everything" - - - "the soap of beautiful women" - - - - "the fragrance men love" . . . Soaps, soaps, soaps! All kinds, all sizes, all colors! But basically soap is still alkali and fat. Forcing air into soap will cause it to float. Adding perfume and color will form a variety of toilet soaps. Transparent soaps are formed by dissolving in alcohol and then removing the solvent. Shaving soaps contain rosin and glycerine to improve lathering and prevent fast drying. Scouring soaps contain some sand, sodium carbonate, and inert fillers. Cresol or other antiseptics are added to medicated soaps. Powdered soaps are prepared by mixing the soap "batch" with sodium silicate and sodium carbonate or similar compounds and with an emulsifying agent such as tetrasodium pyrophosphate; which mixture is then spray-dried. Soaps made with potassium hydroxide are softer and more soluble and are used in the preparation of shaving cream and liquid soaps.

Coming Attractions

"Don't get left - - - - get Dreft!" Have you heard that phrase before? It heralds the newest in the soap industry - - - - synthetic detergents, or "soapless soaps." (Others: Vel, Swerl, Drene, Gardinol, etc.). What are they? Primarily, sodium lauryl sulfate, $CH_3(CH_2)_{10}CH_2NaSO_4$., formed from lauryl acid sulfate by treatment with sodium hydroxide. The acid sulfate is obtained from lauryl alcohol and sulfuric acid.

These compounds are excellent detergents. Their advantage over soap is the ability to lather well in cold and hot water and in hard and soft water. Prepare two equal portions of magnesium sulfate solution. Dissolve a small piece of ordinary soap in one portion and a small quantity of Dreft in the other and compare the quantity of suds formed.

Thus has man advanced himself several thousand years - - - from wood ashes to sodium lauryl sulfate! Happy washday!

Better Than Penicillin?

➤ WHENEVER a new natural product of plant or animal origin is discovered, chemists straightway undertake to make something like it — or better it. They have been trying to do this with penicillin, and at the Atlantic City meeting of the American Chemical Society Dr. Merritt C. Fernald and Dr. Walter B. Geiger of the New Jersey Agricultural Experiment Station announced that they are approaching the goal.

They have prepared a number of synthetic compounds that have much the same effects on bacteria and fungi as the natural antibiotics. The most powerful thus far investigated is known as acrylophenone. It has two drawbacks, however: it is only slightly soluble in water and is closely related to another compound that is highly poisonous to animals. So they are going on with their search for safer synthetic germ-killers.

"Sweettooth" May Help Teeth With Chemical Added to Sugar

Glycerol Aldehyde For Teeth

➤ You WILL be protecting yourself against toothache and tooth decay with every piece of candy you eat and every lump of sugar you drop in your coffee in the future, if a plan proposed at the American Public Health Association meeting at Atlantic City goes into effect.

The plan calls for addition of a simple, tasteless chemical to all sugar at the refineries. It was proposed, as a means of banishing tooth decay at its source, by Dr. L. S. Fosdick of Northwestern University Dental School.

It is hailed as the greatest hope for mass control of caries (tooth decay) yet found, by Dr. Hamilton Robinson, of Ohio State University College of Dentistry and editor of the *Journal of Dental Research*.

Tests of 31 chemicals which might be used in the plan are reported by Dr. Fosdick.

The best so far is one called glycerol aldehyde. This is a triose sugar which is a natural constituent of all muscle. It is harmless, has no objectionable taste and would mix readily with sugar.

It would stop tooth decay by checking the ferment which causes acid to be formed from sugar in the mouth. The acid, if not promptly neutralized, breaks down tooth enamel, removing the calcium, or lime, which makes it hard. Cavities form and the decay process sets in.

The decay process is not a slow, long continued one. Every time you eat sugar, or something with sugar in it, you get a short but very intensive attack of tooth decay. Unless, of course, your mouth has a good mechanism for neutralizing the acid that is formed.

Saliva is the natural neutralizer for acids in the mouth. The very act of chewing practically anything brings a more copious saliva supply into the mouth and thus a more efficient acid neutralizer.

But not everyone has such efficient acid-neutralizing saliva. Some who do may have teeth of such shape and arrangement that food lodges in places where not enough saliva can get at the acid being formed to neutralize it quickly enough.

Eliminating sugar from the diet, so there would be nothing for acid to come from in the mouth, would be one way to stop tooth decay, but very few would choose this way. Special alkaline ash diets to make the saliva a better quality would also prevent decay, but such diets are not very popular.

Best way to attack the problem, Dr. Fosdick thinks, is by a chemical to stop acid formation by checking the ferment that forms the acid. A dozen or more of such chemicals, technically called enzyme inhibitors, have been found and some of them tried.

The fluorine that acts as a tooth

decay preventive in drinking water does this by checking the acid-forming ferment. But fluorine cannot be taken in more than minute amounts. It is a poison and even in relatively small amounts causes an ugly mottling of the teeth.

All the methods so far suggested for preventing tooth decay are so much trouble that, as Dr. Fosdick said, most people would rather have rampant decay than bother with them.

Putting the decay preventive into the sugar at the refineries, however, does away with the bother and gets the preventive to everyone, as almost everyone eats sugar in some form.

Whether glycerol aldehyde is the chemical to use requires further study. If it is not, the plan can still be put into effect when a better chemical is found. Amendment or revision of the Food and Drug laws would be necessary to permit the addition of the chemical to sugar. That could be done, just as it was to permit addition of vitamins to white flour for improving the health of all the people.

Anti-Enzyme Material Fights Germs

➤ A NEW WAY to treat infectious diseases may come from knowledge gained in tests of "sterilized" and unsterilized shoes in connection with athlete's foot.

An anti-enzyme substance which can take the sting out of disease germs by changing them from virulent to non-virulent ones is the possibility reported by J. M. Leise and Prof. L. H. James, of the University of Maryland.

Testing for the athlete's foot fungus in the sterilized and non-sterilized shoes, the Maryland scientists needed a culture medium on which the athlete's foot fungus would grow but on which other, harmless fungi found commonly on shoes, floors and the like would not. When the growth medium was made alkaline, they found, only the athlete's foot fungus grew.

Going a step farther, the Maryland scientists found that an alkaline medium permitted the growth of virulent strains of dysentery germs but checked the growth of non-virulent strains of the same germs.

This relation between disease-producing power of a germ and its ability to stand an alkaline medium may be due to the presence of a trypsin-like enzyme or enzyme system, it appears in the light of previous studies. Trypsin is an enzyme from the pancreas which digests proteins.

"If this were shown to be true," the Maryland scientists state, "it would be possible to use an anti-tryptic agent to change a virulent micro-organism into a non-virulent one and thus aid in treating infectious diseases."

Such material from sweetbreads and soybeans has already been suggested as a weapon against the dangerous hemolytic streptococci in studies by Maj. I. Arthur Mirsky of the Army's Medical Corps.

Photochemistry deals with all reciprocal actions between chemical energy and light energy, including chemical actions that give off light and chemical changes caused by light.

Supergiant Stars Literally Burn Candle at Both Ends

Spendthrift Stars

➤ WHILE THE AVERAGE star is husbanding its resources so well that it can shine for many billions of years, a supergiant star literally burns its candle at both ends at such a rate it soon runs out of atomic fuel, Dr. Lyman Spitzer, Jr., director of the Princeton University Observatory, stated at the Cooper Union Evening Forum in New York recently.

Supergiant stars are more than some 10,000 times brighter than our sun. Those shining today were not shining at their present rate 100,000,000 years ago. The supergiants we see today in our own galaxy and elsewhere will not be shining 100,000,000 years from now. Whereas most of the stars are probably several billion years old, supergiants run out of atomic fuel within a mere 100,000,000 years—a few minutes astronomically speaking.

In explaining how these spendthrift stars were formed, Dr. Spitzer pointed out that supergiants are observed only in regions of highly tenuous and rarefied clouds. These clouds of interstellar matter, observed only in spiral galaxies, absorb starlight in the same way that clouds in our own atmosphere absorb light from the sun.

Study of these obscuring clouds in our own galaxy has shown that they are made up of solid particles so minute that 10,000 of them laid end to end would make a line as long as a period on this printed page, he said. Associated with these tiny solid particles are also individual atoms wandering about in space. Supergiant stars, concentrated in regions rich with interstellar obscuring matter, are believed to be formed continuously from this material.

The first step in the evolutionary process is the sticking together of these individual atoms to form solid particles, pointed out the Princeton astronomer. During the war Dutch scientists showed that individual atoms can condense into solid particles within a few hundred million years.

In the second stage, the individual solid particles are brought together. The tiny solid particles have so little weight that they are pushed around a bit by light from surrounding stars. Two neighboring grains, for instance, tend to be pushed toward each other because the shadow of each falls on the other and cuts off light in that direction. Within a few million years, this radiative force tends to bring all individual solid particles together into different clouds.

In this intermediate stage, the matter is more compressed than in the typical cloud, but more rarefied than in a star. Some small, very compact dark clouds seen in the Milky Way may well be such stars in the making.

As the protostar continues to contract, compressing its inner regions, the temperature inside the star to-be becomes greater until at a temperature of many million degrees, the sources of atomic energy are tapped.

Practical Projects:

Setting Fruit With Chemicals

by J. Albert Starkey

Head of Science Dept., Vineland High School, Vineland, N. J.

A project correlating chemistry with agriculture or biology. It requires a greenhouse, a conservatory or an expanse of sunny windows.

▶ It is now standard practice among greenhouse tomato growers to produce the fruit with the aid of certain chemicals which cause setting of fruit in spite of adverse growing conditions. Short hours of daylight and temperature fluctuations from day to night seriously affect the setting of fruit. Pollination is sometimes effected by hand, or on a larger scale, by mechanical vibrators. However, during the past ten years experiments with various growth regulating agents—the so-called plant hormones—have led to the use of various organic chemicals to cause parthenocarpic setting of the fruit. By this method, pollination is unnecessary and the fruit will grow to normal size whether pollination has occurred or not. The action of the chemical on the plant causes development of the ovaries into tomatoes which frequently have no seeds at all.

The commercial practice is to spray the flowers at regular intervals with a solution of indole butyric acid and beta naphthoxyacetic acid. For the purpose of this project small quantities of the following chemicals may be obtained from the usual sources: indole butyric acid, beta naphthoxy acetic acid, alpha chlorophenoxy propionic acid, 2,4 dichlorophenoxy acetic acid. Many other compounds have similar effects but those named are the most productive of results.

The greater the number of plants available for the project the more trials can be run. At least two plants should be used for each solution and two or more remain untreated as controls. The plants can be produced from seed started outdoors or in flats indoors. We used plants produced from seed planted in a flat in August. When about two inches tall, they were transplanted to four-inch pots and remained in them outside until the approach of frost required that they be moved inside. However, the entire growth should be of a forcing variety for best results. Michigan State Forcing is one of the best varieties available for this purpose.

When the plants were about eight inches tall, we planted them directly in the bench in the greenhouse. They were planted about two feet apart in a rather narrow bench. Wires were immediately put in place to support each plant as it grew. During the full time of the trial, all side branches were removed as they appeared so that the plants grew as single stems, eventually reaching a height of seven feet.

During the entire growth of the plants they were watched very carefully for deficiency symptoms so that

the needed elements could be supplied. This led to a study of the elements necessary for plant growth and particularly to the effects of a lack of these elements on the growth of plants. At the first appearance of any symptom of a deficiency, chemicals were used in a sufficient amount to remedy the condition. At this point a project in soil testing and determination of remedial measures could be developed. We did not, since we did not care to expand our activities at the time. The judgment of the teacher was relied upon to determine the probable amounts to use. Results by this method were very satisfactory. We used pure chemicals in order to get close control with small amounts but undoubtedly commercial fertilizers could be used. All these chemicals were applied in water solution.

Solutions of the growth regulating chemicals were prepared in several concentrations. The amounts needed are very minute ranging from five to fifty parts per million, (p.p.m.). We made solutions of each chemical used in concentrations of 10 p.p.m. and 25 p.p.m. Ten milligram and twenty-five milligram portions of each were weighed and dissolved in the smallest possible amount of ethanol. Each portion was then made up with water to one liter of solution. These solutions are ready for use. They may be prepared in more concentrated form and diluted as required for use. We tried both methods and settled on the ready-for-use solutions.

The solution must be sprayed on the fully developed flowers of the plants in such a way that some of the solution reaches the ovaries. We used a nasal type atomizer since with it a fine spray could be directed into each flower. It is necessary that each flower be sprayed, preferably when it is in full bloom. One spraying is sufficient on any flower but no harm is done if it is sprayed again. Flowers sprayed before full bloom usually do not develop. Since all the flowers in a cluster do not bloom at the same time the spraying must be repeated at three day intervals in order that all the flowers be treated. It is better that parts of the plants other than the flowers not be sprayed since undesirable vegetative effects may result from some of the chemicals used. 2,4-dichlorophenoxy acetic acid is one which has this kind of action. It will be recognized as the common 2,4-D weed killer. It is an excellent weed killer in some concentrations but is also a growth promoting agent in lesser concentrations.

We sprayed each cluster of flowers according to the previously stated schedule. Results were noticeable in a few days. The sepals of the flowers showing results became enlarged and the petals were retained at the stem end of the fruit and in some cases were still evident there thirty days later. The ovaries began to enlarge and the miniature tomatoes gained rapidly in size. During this time, we supplied plenty of water containing dissolved plant food.

The ripening time was somewhat longer than expected, probably because of the short hours of daylight and fluctuations in temperature which we found it impossible to control. The heat supplied to the greenhouse varied as the heat in our building and we found it necessary to add supplementary heat by means of infra-red lamps.

Differences in the effect of the various solutions were soon evident. Some clusters showed every fruit developing but remaining rather small. Some showed development of part of the cluster. In one case the tomatoes had sunken sections and looked very much like peppers. Several plants had tomatoes ripening at four levels at the same time.

When finally some of the tomatoes were fully ripe we cut them to examine the interiors. The sunken specimens, as suspected, contained no seeds and simply had not filled out where the seeds normally would be. Some nice round ones also were seedless but the seed cavities were filled with a gelatinous material. Some contained a very few seeds. Certainly none of them would have grown at all without the spray. The absence of seeds indicates lack of pollination and normally unpollinated flowers do not develop into fruit.

The tomatoes were of excellent flavor, and were praised by all the lucky ones who ate any of them. Of the various materials tested, indole butyric acid produced the most consistent results, while 2,4-dichlorophenoxy acetic acid was effective in the lowest concentration.

In addition to the satisfaction of producing excellent tomatoes in a novel way, the pupils have had the opportunity to make close observation of plant growth and fruit development. Some pupils may be encouraged to follow gardening as a hobby, or agricultural chemistry as a career. Those pupils already interested in agriculture have observed deficiency symptoms and plant requirements. All pupils can learn to make standard solutions using very small quantities of solute. The manufacture, composition and uses of certain organic compounds have been studied. Study and investigation of published material of research scientists has stimulated the interest of the pupils in science.

CHEMISTRY *invites other contributions to this department. Teachers who have developed successful projects, up-to-date and a little out of the ordinary, who would like to pass them on to others, and individual researchers and hobbyists with the same urge may communicate here with kindred spirits. The department will appear from time to time as space permits. Manuscripts should be typed, double space, on one side of the paper, and should be approximately one thousand words in length.*

Colchicine Speeds Plant Growth

COLCHICINE, the "evolution chemical" that has been used to originate new species of plants by multiplying the heredity-bearing chromosomes of old ones, also has the power of greatly speeding up plant growth when used in weaker concentration, Prof. Earl H. Newcomer of the University of North Carolina has found. He used a 0.4% solution and placed one drop of this per day on the growing points of young oak and chestnut trees, hazel bushes and other plants. In some cases the treatment produced unfavorable results, even death, but in 16 seedlings of the species named he found that growth went on at double the usual rate.

Molecular Sedimentation In the Ultracentrifuge

Sorting by Super-Gravity

by THE SVEDBERG

Reprinted from Endeavour, London.

➤ THE SEDIMENTATION or settling of small particles under the influence of gravity is an everyday phenomenon which plays, and has played, a great part in geophysics. Clay deposits, old and recent, are formed through the fractionating effect of the sedimentation of particles carried by the water of streams and rivers to the lakes and the ocean. With decreasing size of particle the sedimentation becomes slower and slower, until the inevitable thermal convection currents stop it altogether. The greenish colour of many glacier lakes is due to minute particles floating in the water.

If the size of the particles is further diminished, to molecular dimensions, another phenomenon comes into play, namely the diffusion or irregular thermal motion of the individual particles or molecules. The atmosphere surrounding the earth is kept from flying away into planetary space by sedimentation, and is prevented from settling down as a dense layer on the surface of the earth by diffusion. The state resulting from this combination of sedimentation and diffusion is called sedimentation equilibrium. If we want to use the sedimentation of molecules for analytical purposes in the laboratory, the force of gravity has to be increased hundreds of thousands of times. This can be accomplished by means of swift rotation in a specially designed centrifugal apparatus, the so-called ultracentrifuge.

The first measurements of molecular sedimentation were performed at Upsala in an oil-turbine ultracentrifuge constructed for that purpose. Since then other types of ultracentrifuge have been devised, using compressed air or electric current of high frequency as the driving agent. Whatever the driving force, the solution to be studied has to be enclosed in a small cell of sectorial shape with windows for optical measurements. This cell has to be mounted in a rotor spinning at constant temperature in hydrogen at low pressure, or in a perfect vacuum.

Particles Travel on Radii

Particles or molecules in a centrifuge travel towards the periphery along radii, hence the sectorial shape of the cell. Constant temperature has to be maintained in order to avoid disturbing convection currents. In the case of the oil-turbine ultracentrifuge the rotor is provided with two small turbines, one at each end of the shaft, acted upon by oil under pressure. To avoid vibration the rotor and its cell are carefully balanced, and the bearings are provided with a special damping device. A solid steel casing protects the observer and instruments in case of failure of the rotor material.

The methods of observation used so

far are based on either the absorption or the refraction of a beam of light passed through the rotating cell. The former is more direct and easier to understand, the latter more precise.

In the former case each molecular species shows up as a step on the curve, in the latter as a peak. By such methods the molecular composition of a solution can be studied. If only a few molecular species are present, each of them of definite mass and shape, the analysis is comparatively easy. This is the case with many of the native proteins. Other substances of high molecular weight, such as the polysaccharides, consist mostly of molecules of continuously varying size. In the sedimentation diagram this shows up as a marked broadening of the peak.

There is always a certain degree of broadening due to the diffusion or thermal motion of the molecules, but it is much slower in the case of large molecules such as those of cellulose. . . .

The unequal size of the molecules —the so-called polydispersity—shows up in the diffusion curve in a peculiar way. For a solution containing only one molecular species the broadening of the curve follows the simple statistical laws. In the case of a mixture, however, there is a marked deviation. The molecular weight can be calculated from sedimentation and diffusion according to the formula:

$$M = RTs/[D(1 - V\varrho)]$$

where M = molecular (or particle) weight,
R = gas constant,
T = absolute temperature,
s = sedimentation constant,
D = diffusion constant,
V = partial specific volume of solute,
ϱ = density of solution.

As already mentioned, the combined result of sedimentation and diffusion finally leads to a steady state, the so-called sedimentation equilibrium. The number of molecules per unit volume decreases exponentially in the direction of diminishing force. Thus the density of the atmosphere around the earth falls to half its ground-level value at an altitude of about 6,000 metres, while for a serum albumin solution exposed to a centrifugal field 10,000 times the force of gravity the corresponding distance is only 1 mm.

Owing to the fact that sedimentation equilibrium is dependent upon both sedimentation and diffusion, the molecular weights can be found directly from such determinations by means of the formula:

$$M = \frac{2RT \cdot log(c_2/c_1)}{(1 - V\varrho)\omega^2(x_2^2 - x_1^2)}$$

where c_1 and c_2 are the concentrations at the distances x_1 and x_2 and ω is the angular velocity.

The measurement of molecular sedimentation by means of the ultracentrifuge has proved a very useful analytical tool in many branches of science, medicine, and industry.

The blood of all vertebrates and many invertebrates contains a variety of respiratory pigments, either enclosed in corpuscles or simply dissolved in the blood-fluid. The bluish haemocyanins of the snails and crustaceans have molecular weights of the order of millions. Many of these types of

molecule undergo dissociation reactions when the environment is changed, resulting in a splitting of the molecule. The reactions are often characteristic of the genus and species.

Thus the haemocyanin in the blood of the snails *Helix* is stable only within a certain *p*H range. Outside this region the molecule is dissociated into well-defined clevage products with molecular weights one-half and one-eighth that of the original molecule. The parts have the same length as the parent molecule. The haemocyanin of *Helix pomatia* can also be split by the addition of salt. Curiously enough, only three-quarters of the molecules present are sensitive to salt; the rest remain undissociated. Evidently there are two chemically different kinds of haemocyanin molecules present in the blood of *H. pomatia*: one is split both by *p*H change and addition of salt, the other by *p*H change only.

There is a second type of snail haemocyanin which is split by a change in *pH* but not by salt (example: *Paludina vivipara*), and a third type which is split only at extremely high *p*H values and not by salt (example: *Buccinum undatum*).

Blood Relations of Fish

The origin of the lowest class of the vertebrates possessing red corpuscles, the *Cyclostomata* (lamprey and hagfish) has long been a question of controversy among taxonomists. The opinion now generally accepted looks upon these worm-like fishes as belonging to a very ancient side branch on the genealogical tree of the vertebrates, far removed from other living animals. The determination of the molecular weight of the red blood-pigment for the various groups of vertebrates by means of the ultracentrifuge gave the result that all vertebrates, including the different types of fish, with the exception of the *Cyclostomata*, show a value of about 69,000; the *Cyclostomata*, however give a value of only one-fourth of this, or 17,500. Sedimentation analysis, therefore, strongly supports the result arrived at from morphological, anatomical, and palaeontological indications. To put it crudely, man is more closely related to the salmon than the salmon is to the lamprey.

Lilium Types

Many other instances of the use of molecular sedimentation analysis in taxonomy could be given, but only one more, from the field of botany, will be cited here. The sap in the bulbs of the *Liliiflorae* contains polysaccharides and sometimes also proteins in solution. An ultracentrifugal investigation gave the following result. Among the species of the same genus there is a pronounced similarity with regard to the material of high molecular weight. The *Lilium* species, for instance, contain a large amount of polysaccharide, while species of *Fritillaria* and *Tulipa*, belonging to the same subfamily as *Lilium*, contain more protein than carbohydrate and show sedimentation diagrams quite different from those of *Lilium*. There is one very interesting exception: *Fritillaria kamchatkensis*, which is closely related to the *Lilium* (and which has been placed by some taxonomists within this genus), yields a diagram of the *Lilium* type.

The medical applications of ultracentrifugal sedimentation are numer-

ous. One of the most interesting examples is the disentanglement of the complicated protein system of the blood-plasma. Normal serum shows three boundaries. The first one, the so-called 20-component fraction, sediments to the bottom of the cell in about forty minutes under standard conditions (room temperature and 250,000 times gravity). In concentration it corresponds to only a few per cent of the total protein in the serum. Its molecular weight is of the order of half a million. At the same time as the first boundary reaches the bottom of the cell, a second broad boundary has usually just separated from the top of the solution. As it moves towards the periphery it eventually splits into two boundaries. The first, and smaller, one reaches the bottom in 1½—2 hours; it has a molecular weight of 150,000—180,000, and in concentration it amounts to 10—20 per cent of the total. Finally, the major part of the protein sediments in the last boundary, which reaches the bottom of the cell in about three hours. This boundary, however, does not correspond to a single substance, but represents protein called β-globulin as well as the serum albumin. The composite nature of the third boundary is easily demonstrated in the case of normal human serum. If, before the run, the serum is diluted with an equal volume of 0·2 molar disodium phosphate instead of with physiological saline, the third boundary will separate into two boundaries toward the end of the run. The first and bigger boundary shows the same sedimentation as before. It consists of the serum albumin, which has a molecular weight around 70,000. The more slowly moving boundary consists mainly of β-globulin, which is a lipo-protein. The density of this protein is close to 1, whereas the density of most other proteins is about 1·3. The sedimentation of the lipo-protein is therefore much more dependent on the density of the solution than that of the other proteins. This property of the lipo-protein has been used for its separation from normal human serum.

Up to the present no other mammalian sera have been found to contain such a low-density lipo-protein as the one in human serum. There are, however, many reasons for believing that other mammalian sera also have a β-globulin which sediments with the albumin, but its lipid part has a higher density than the human one.

All Vertebrates Similar

The general appearance of the sedimentation diagram from normal adult mammalian serum seems to be qualitatively the same for all species, but there are usually some small quantitative differences. Even the lower vertebrates seem to give qualitatively the same sedimentation diagrams as the mammals do. The *Cyclostomata,* however, have a minor component with a molecular weight of about 35,000 and a major component with a molecular weight of about 360,000.

The sedimentation diagram for a given animal is not always the same, but varies with its age. Thus the ultracentrifuge has revealed that a hitherto unknown serum protein, now called fetuin, is present in many foetal sera and in sera from newly born animals. It has a lower mole-

cular weight (around 50,000) than any of the previously isolated serum proteins.

Antibody production during the process of immunization is often manifested in the serum diagram as an increase in either the so-called γ-globulin or in the heaviest protein component. Some diseases also produce great changes in the serum sedimentation diagrams, and it may be possible, for instance, to classify various myelomas according to the sedimentation diagrams obtained from the patient's serum.

The changes in a serum due to the increasing age of the animal may be illustrated by bovine serum. In the foetal serum diagram hardly any γ-globulin is perceptible. Besides an asymmetric peak consisting of albumin and fetuin, a small amount of a heavy component is present. A similar diagram is obtained from the serum just after birth. Some time after the calf has received colostrum, γ-globulin appears in the serum diagram. During the first weeks after birth the fetuin and the γ-globulin decrease. Later the fetuin practically disappears, whereas the γ-globulin increases, when the natural immunity is being built up, until it reaches its 'natural' level.

Study of Viruses

Another medical application is in the study of viruses. Directly after the first preparation of virus crystals (tobacco mosaic) the analytical ultracentrifuge was used for the determination of the mass of these huge molecules and to compare various strains of virus. A great number of such determinations have been made during the last ten years.

Sedimentation measurements in the ultracentrifuge have proved very useful as a means of following the process of purification of a virus. As an example, the isolation of poliomyelitis virus from brain tissue or intestinal contents may be mentioned.

Industrial Uses

Many industrial problems concerning material of high molecular weight belonging to the polysaccharides and to various groups of synthetic organic polymers have been studied by means of ultracentrifugal sedimentation. The most important of the macromolecular carbohydrates, from a technical point of view, is cellulose. It occurs in a fairly pure state in certain fibres such as cotton and flax. Native cellulose, however, generally occurs in combination with other carbohydrates and with lignin, and its liberation requires rather drastic chemical treatment (the sulphite and sulphate processes).

For many purposes the industrially prepared cellulose should contain molecules consisting of the longest possible chains of glucose groups, and it is often considered advantageous that the length of the individual molecules should be nearly equal (monodisperse). In the industrial processes for isolating cellulose from wood a considerable degradation takes place, especially during the later stages. The chain molecules break, and shorter and more unequal (polydisperse) pieces result. It is of considerable importance to find the most favourable conditions for producing a cellulose of a specified molecular type. Investigations of this kind have been carried out by means of the ultracentrifuge.

Industrial wood cellulose manufactured according to the sulphite process is broken down considerably, and the amount of wood polyoses is diminished.

In such cases as cellulose, where the broadening of the sedimentation curves is caused entirely by the different rate of sedimentation of the individual molecules, a measure of the polydispersity is obtained by calculating dB/dx, the rate of broadening with increasing distance from the centre of rotation.

The complete description of a polydisperse material such as cellulose requires the determination of the distribution or frequency curve for the weights of the molecules. This problem is very difficult, and so far only approximate solutions have been found.

Among the synthetic high polymers and their natural prototypes rubber plays an important role. The technical value of various types of rubber depends to a considerable extent upon the size and shape of the molecules. Here sedimentation analysis in the ultracentrifuge has furnished valuable information. In the case of neoprene it was found that bulk polymerization gives molecules of simple chain type, while certain kinds of emulsion polymerization produce molecules of a more branched type. For most purposes it is desirable to obtain a rubber with simple chains, and therefore the polymerization process should be conducted in such a way as to yield that type of molecule. Also in the case of plastics, such as polystyrene, methyl methacrylate, and other polyethylenes, the ultracentrifuge has been used for the control of industrial processes.

Improved Cellulose Gum

➤ IMPROVED WATER-SOLUBLE cellulose gum, with hundreds of manufacturing uses ranging from tooth paste and paints to chinaware and rubber, has entered commercial production in a new plant of the Hercules Powder Company, at Hopewell, Va.

Cellulose gum is not a new product; it has been made in Europe for many years where it is known as sodium cellulose glycolate. Little, however, has been made in America until now, but it will become plentiful as a result of Hercules processes.

The new Hercules cellulose gum will be known as CMC. It is the sodium salt of carboxymethyl-cellulose formed by the reaction of monochloroacetic acid with alkali cellulose. It is adhesive but not sticky. It is insoluble in organic solvents; it not only acts as an emulsifying agent in oil-in-water emulsions, but also protects the emulsion. Many of the various uses for which it is suitable are due to it being an emulsion stabilizing or suspending agent.

Approximately 2,000,000 pounds of dynamite was used in driving the new eight-mile irrigation Alva B. Adams tunnel through the Rockies in Colorado.

Frivolous Effervescence *and* **Caustic Comment**

by Our Readers

➤ "Another angle which needs attention," says Miss I. M. S. of Indianapolis, "is emphasis on courses in technical German, Russian and French in our schools. Russian has now become the third language of chemistry. Where will we find linguists with technical training? Should not the problem be presented to the educational world as a real need so they can make plans for courses and also include the relation of languages to science in vocational advisory service?"

* * *

➤ Quotations from new books Brother H. of Panama City finds of interest to him.

* * *

➤ A good suggestion comes from H.B.C., Ft. Lauderdale, Fla. "Many is the time that I have saved a lot of time by dissolving an unknown substance, crystallizing it on a slide and viewing it in a microscope. For many substances it is a 'dead give-away,' as one young chemist (age 12) said."

* * *

➤ "Do physicists believe that is is possible that there exist atoms smaller than hydrogen? I know that hydrogen is composed of only one proton and one electron, but is it possible that there exist smaller bits of matter than the proton and electron which have positive and negative charges, or could atoms be detected by scientific instruments now in use, if they exist?"

—R.B., Beacon, N. Y.

* * *

It is the Editors' private and highly unorthodox opinion that one of the funniest sights in the world is going to be the red faces of the physicists when the chemists discover one or more elements lighter than hydrogen. Until that unlikely day arrives, here is our best answer to R.B.'s problem.

➤ Hydrogen is still the lightest of the substances known to chemists as ele ments. Its mass is taken as *one*. Atomic weights of the other elements are really ratios, showing how many times heavier than hydrogen comparable quantities of them are.

Physicists, interested primarily in the structure of the atom, consider the hydrogen atom one of the units making up all matter.

In chemical reactions, hydrogen combines with a positive valence of one. To the physicist, this means that it forms its compounds because it has lost one electron from the outside orbit of its atom. He assumes that, being the unit atom, hydrogen has only a nucleus and one electron. This may or may not be true, but he has no reason to doubt his theory.

After losing its one electron, the hydrogen nucleus has a unit positive charge. To the chemist it is a hydro-

gen ion. The physicist, who looks upon it as one of the fundamental particles of the universe, calls it by a different name—the proton.

Hydrogen, therefore, consists of a proton plus an electron. Whether this proton is the ultimate chemical nucleus, or whether there are new and strange configurations of matter and electrical charges packed inside it is one of the frontier problems of chemical physics today.

There is, however, another ultimate particle of approximately the same mass as the proton, but with no electric charge. This is the neutron, discovered by Chadwick in 1934. Chemically, it diffuses like a gas and forms no compounds, so that it is being written into the Periodic Table as the lightest of the inert gases in Group 0. Its symbol is ${}_0n^1$. That practically qualifies it as an element, but, since its mass is the same as that of ${}_1H^1$, the atomic masses of the other elements would not have to be revised if it were declared the lightest element.

Atomic weights have come to be of secondary importance for theoretical purposes, anyway. Elements are ranked according to atomic number, and nobody seems to mind beginning the series with No. Zero.

A peculiar perverseness has dogged the naming of electrical entities. In many of its manifestations, *negative* electricity seems to be the only kind there is, and what we have happened to call *positive* electricity merely the lack of it. This wrong-side-out approach would be consistent for remembering chemical charges, except that in 1933 an actual unit of positive electricity, existing as a particle like the electron but of opposite sign, was identified by physicists studying cosmic rays.

This particle, 1800 times smaller than the proton (hydrogen ion) and positively charged, is called the positron. The positron seems to exist only momentarily, then to combine with an electron, which results in their mutual disappearance into radiant energy.

Transformations of state between matter and energy are so contrary to what scientists believed possible up to a few years ago that physicists are having a hard time revising their former concepts to accommodate them.

Then, in 1938, subatomic physics became further complicated by the discovery of the mesotron (or meson), with unit negative charge like an electron but several hundred times the electron's mass. Mesotrons also have a very short life, and break up into electrons and radiant energy.

All these particles register on detecting apparatus of one kind or another—electroscope, Geiger counters, photographic plates, or what-not—or else they would not have been discovered.

What marvels there may be in the universe that do not reveal themselves to our senses but await recognition by some still-to-be-designed instrument is something to grow slightly dizzy over in one's spare time.

Adding pectin to fruit jams produces a product that can be packaged in paper.

Evidence for Three
Discoveries of No. 61

Rarest of the Elements

A Classic of Chemistry

➤ In how many ways can an element be discovered? Which isotope can best claim to the "real" element? And how can you prove that you once had a sample of an element in your possession if meanwhile it has turned into something else?

These are some of the questions to be settled by chemical referees in the problem of naming Element No. 61. One of the possibilities they must face is that they may be dealing with a substance so rare that it cannot exist at all in stable form.

Three American claimants to the right of naming this missing rare earth element base their respective claims on three different ways that an element may be discovered.

The first is the classical method of separating it from its fellows by analyzing a naturally-occurring mineral. That is the way Dr. B. Smith Hopkins believes he discovered the element in 1926. He named it Illinium (Il). He admits that he never had much of it, and that what he did have was probably not a pure compound. But it showed lines in its spectrum that separated it from its nearest neighbors, neodymium (60) and samarium (62), and that is the sort of evidence that discovery of most of the other rare earth elements rests upon.

A second method of discovery is illustrated by the work done by J. D. Kurbatov, L. L. Quill, M. L. Pool and their associates at Ohio State University in deliberately bombarding compounds of neighboring elements to try to produce artificial isotopes of the element that is so elusive in nature. Their work was done in 1941, with a cyclotron. In honor of the instrument and method, they have proposed Cyclonium (Cy) as the name for the element thus produced.

Thirdly, there comes the group of chemists at M.I.T., J. A. Marinsky, L. E. Glendenin and C. D. Coryell, who, while in the secret fastnesses of Oak Ridge, devised a method of separating by ion exchange reactions the fission products given off by the atomic pile. Here, for the first time, element 61 appears in any satisfactory quantity. Impressed by the likeness of the birth of atomic energy to man's first mastery of fire, this group wants to call its version of the element Prometheum (Pm), after Prometheus, the demi-god who first gave that boon to man.

Until atomic power research gave scientists greater familiarity with the ways of radioactive isotopes than they had had during the 50 years since the discovery of radium and its decomposition products, chemists hesitated to accept as real elements short-lived isotopes of elements such as had been

christened Polonium and Actinium. Prejudice against unstable forms doubtless played its part in disqualifying Dr. Hopkins' Illinium. On the one hand, his group did not take much interest in their evidence of radioactivity among the rare earths. On the other, objection to the new element centered around its instability. Now that radioactive transmutations are better understood, transitory isotopes are admitted to the list of elements, as in the case of the recent naming of 87 as Francium (Fr) and 85 as Astatine (At).

On account of the unusually interesting circumstances in the naming of this element, CHEMISTRY presents as Classics the original accounts of the earlier researches and a short extract from the new announcement of work on this rarest of the elements.

Illinium

ILLINIUM "61." *Industrial and Engineering Chemistry, News Edition, 4:6 (March 20, 1926).*

➤ IN THE COURSE of the work of mapping the arc spectrum of the elements, which was carried out by the Bureau of Standards in 1920, data on some of the rare earth elements was taken from observations on samples which had been procured from the laboratory of the University of Illinois. These samples had been obtained by extensive fractional crystallization of salts obtained from monazite sand residues. In the course of the investigation it was found that the samples of neodymium and samarium (elements 60 and 62), which were supposedly very pure, showed faint arc spectrum lines which were common to both samples and which could be attributed to no known element. These strav lines, which were about one hundred thirty in number, were recorded, and appeared in the *Scientific Papers* of the Bureau of Standards, Vol. 18, page 218. At that time the suggestion was made that these strange lines in the spectrum of neodymium and samarium might be indications of the undiscovered element, No. 61.

Following this lead, fractionation of samples of neodymium and samarium was continued in the laboratory of the University of Illinois, under the direction of Professor B. S. Hopkins. Crystallizations were carried out on various salts of the rare earths over a period of several years. X-ray investigation made by Dr. L. F. Yntema in 1922 on some of the most advanced fractions indicated that the concentration of the new element was, at that time, less than one-tenth of one per cent. During the course of this work, five additional lines were found toward the violet end of the arc spectrum. It was found out later by Mr. J. A. Harris that when the material was fractionated as the bromate, an absorption band, which formerly had been attributed to neodymium, became faint in the pure neodymium sample, and became more prominent in the samples that were intermediate between samarium and neodymium. This band, coming at about 5810 Å, seemed to correspond very definitely to that which would be expected from the new element. The intensity of this band was used as a guide in the progress of the fractionations as the

work continued over an additional three-year period. The final X-ray investigation confirming the presence of 61 which has just been carried out by Mr. Harris, Dr. Yntema, and Professor Hopkins, was made on samples which have been the result of this five years' work.

The line that has been obtained is the L-alpha line for 61 as calculated from Siegbahn's values. This line shows faintly but distinctly on two plates from each of two samples of material. The lines vary from the calculated value by plus thirty to minus forty ten-thousandths of an Ångström unit. The claim for the presence of the new element is based on three separate points of evidence.

1. The presence in the arc spectrum of one hundred thirty-five lines whose wavelengths do not check with those shown by any known element.

2. The presence in the absorption spectrum, of the intermediate fractions between neodymium and samarium, of a band at 5810 Å, where the band for 61 should appear.

3. The presence of faint X-ray lines from two fractions in position corresponding, within the limit of experimental error of the apparatus, to that calculated for the L-alpha line.

The name proposed for the new element is "Illinium," with the symbol, "Il."

Cyclonium

RADIOACTIVE ISOTOPES OF ND, IL AND SM. *H. B. Law, M. L. Pool, J. D. Kurbatov and L. L. Quill, Ohio State University. In Physical Review, 59: p. 936 (1941).*

➤ PR, ND AND SM have been bombarded with 10-Mev deuterons, 5-Mev protons, neutrons and gammas from deuterons and protons on lithium metal, respectively. Several new periods were found, tentative values of which are listed.

In all cases chemical separations were performed to eliminate isotopes that do not follow the rare earths. Since the 108-day period occurs with Pr + α and Nd + α it may be ascribed to ${}_{61}Il^{144}$. The 3.7-hr. and 17-hr. periods found with Pr + α can be analyzed as isotopes which are rare earth group elements after bombardment. The 2.3-hr may be either ${}_{61}Il^{147}$ or ${}_{61}Il^{149}$ if one postulates a fast period for ${}_{60}Nd^{147-9}$ which decays by electron emission to Il.

	Pr	Nd	Sm
α	(3.7 hr, 17 hr, 108 days)	(2.3 hr, 10 days)	
d		(2.3 hr, 47 hr, 10 days, 108 days)	(21 min, 9 hr, 47 hr, 60 days)
n		(2.3 hr, 47 hr, 10 days)	(21 min, 47 hr)
p		(2.3 hr, 6 days)	
γ		(2.3 hr, 10 days)	(21 min, 47 hr)

FURTHER PROGRESS *on the study of the radio-active isotopes of the Nd-Il-Sm region. J. D. Kurbatov, D. C. MacDonald, M. L. Pool, and L. L. Quill, Ohio State University. In Physical Review, 61:p-106.*

➤SINCE THE PREVIOUS report on this study, the following additional data have been secured:

A. The reactions, Sm + *d*, Sm + *n* (fast) and Nd + *a*, produce the isotopes tentatively assigned to the element samarium, as follows: (*a*) the isomers 21 ± 2 min., β^- - 1.8 Mev emitter and 60 ± 6 days, γ^- emitter; and (*b*) a 47 ± 1 hr, β^- low upper limit energy emitter. The short period of about 2.4 min, β^+ emitter was always present but cannot be definitely assigned as yet.

B. The reactions, Nd + *d*, Nd + *n* (fast), Nd + γ, and Pr + *p*, produce the isotopes assigned to the element neodymium, as follows: (*a*) a 2.5 hr, β^+ 0.78 Mev emitter assigned to Nd^{141}, (*b*) a 41 ± 1 hr, β^- 2.9 Mev emitter. Two additional periods, one of about 2 hr, β emitter, and the other a short one, are being studied.

C. The reactions, Pr + α and Nd + *d*, produce an isotope, >100 days, β^- emitter. The Nd + *a*, Nd + *d*, and Nd + γ reactions produce a β^- emitter of about 10 days half-life, and possibly two shorter period substances. Additional studies are in progress to clarify further the assignments of periods to the proper isotopes of Nd, Il, Sm.

Prometheum

THE CHEMICAL IDENTIFICATION *of Radioisotopes of Neodymium and Element 61. J. A. Marinsky, L. E. Glendenin and C. D. Coryell. In Journal of the American Chemical Society, 69:11 (1947).*

➤IN THE COMPREHENSIVE studies of the radioactive species produced in the fission of uranium it has been found that over thirty are members of the rare earth family (isotopes of yttrium and the group lanthanum through europium). The chemical and physical identification of these was an important part of the research program of the Manhattan Project. Standard oxidative separations and fractional precipitations and the use of radiochemical methods based on chain relations served to distinguish the activities of yttrium, lanthanum, cerium, and some of praseodymium, and those of samarium and europium. The characterization of the sequence praseodymium, neodymium, and element 61 presented very difficult problems that were solved only with the intensification of ion exchange methods originally developed by Boyd and co-workers and applied to the rare earth field by Cohn and co-workers. In this paper is reported the successful separation of these three elements, the first to have been achieved with radioisotopes of neodymium and of element 61.

Earlier work on the Manhattan Project had revealed the presence of two unidentified fission products in the rare earth region. A soft beta emitting activity of about 4y half-life was discovered by Ballou and independently by Goldschmidt and Morgan. This activity was later studied by

Seiler and Winsberg who set the half-life at about 3.7y. These investigators considered the activity to be an isotope of praseodymium, neodymium, or element 61 on the basis of detailed qualitative chemical separations between lanthanum and praseodymium. Another unidentified rare earth activity was later discovered by Davies through its characteristic gamma radiations. This was confirmed by Hume and Martens who determined its half-life as about 11d and showed that the activity was not cerium. We have been able to identify these two activities as isotopes of element 61 and of neodymium, respectively, both of mass number 147. In addition the 47h 61^{149} has been identified among the fission products. All three of these activities, together with a previously unidentified 1.7h isotope of neodymium, are also produced as the result of the activation of neodymium with slow neutrons.

Chemical Identification

The 11d activity was first subjected to standard qualitative separations in order to limit the identification problem to a definite group of rare earth elements. Separations by carbonate digestion definitely eliminated yttrium and all rare earth elements of atomic number greater than 61. Oxidative fusion with sodium nitrate demonstrated that the activity was not an isotope of lanthanum and must therefore be identified with praseodymium, neodymium or element 61. Finally, the activity was limited to an isotope of neodymium or element 61 by demonstration of separation from praseodymium with potassium hydroxide fusions.

Positive identification of the 3.7y and the 11d radioisotopes was then achieved by the recently developed ion-exchange method using a synthetic organic cation exchanger (Amberlite IR-1) of the sulfonated phenol-formaldehyde type. This new method provides very effective separations of the rare earths, even between adjacent elements. The procedure involves the adsorption of the rare earth ions on a column of the resin from dilute acid solution followed by elution with 5% citric acid adjusted to a pH of about 3 with concentrated ammonia.

The order of elution of the rare earths (from lanthanum through europium and yttrium was established in a series of experiments using radioactive cerium, lanthanum, europium and yttrium produced in fission and radioactive praseodymium and europium produced by slow neutron activation of pure oxides. Macroscopic quantities of samarium, europium, and neodymium with spectrographic analyses were also used. The results of these experiments show clearly that the order of elution of the rare earths is the reverse of that of atomic number, and that consequently the atomic number of an unknown radioisotope can be determined from the elution curves of a group of successive rare earths. Yttrium is eluted in the region of gadolinium as might be expected from its well known behavior in precipitation work. . . .

The 11d and the 3.7y activities were identified in the following experiment. A sample which contained essentially the praseodymium group (praseodymium, neodymium and element 61) with very little cerium, samarium, europium, and yttrium activities (by virtue of thorough chemical removal

of cerium by ceric iodate precipitations and of yttrium, samarium, and europium by repeated digestions with potassium carbonate), was isolated with about 15 mg. of lanthanum carrier from a rare earth fission product elution fraction intermediate between cerium and yttrium that was supplied by Cohn and co-workers. The rare earth activities in this sample were absorbed on an Amberlite IR-1 column and eluted with a 5% solution of ammonium citrate at a pH value of 2.75. Fractions of the eluate were collected, and the observed beta and gamma activity in each fraction was plotted against the volume of eluate that had passed through the column. Four beta peaks were observed . . . The gamma activity 11d half-life) was found to be associated with the third peak.

The activity of the first peak was very low. It was identified as 57d Y^{91} (1.5 Mev. beta energy) from aluminum absorption curves. It is esimated from the curves that about 0.001% of the original yttrium was present in this experiment. Consideration of the fission yields and half-lives of fission product activities indicates that no appreciable activity of samarium and europium would be found even though contamination from these elements should exceed that from yttrium by a factor of about one thousand. The remaining peaks must thus be ascribed to element 61, neodymium, and praseodymium in that order. . . .

Quantity Available

Considerable quantities of 61^{147} can be prepared as the result of the industrial application of nuclear power. A uranium pile operating at the power level of 1,000 kw. produces about 3×10^{16} fissions per second. From the data in Table I.* it is seen that 2.6% of these will lead to chain 147. There is produced, therefore, about 16 mg. per day of Nd^{147}, which, after suitable decay, is transformed into 61^{147} of sufficient half-life for isolation and chemical study. The activity associated with 1 mg. of the species is 0.66 curie but the radiations consist solely of soft β rays that are easily shielded and should not interfere too greatly with chemical operations.

* **Not reprinted here. The reader will want to look up the whole of this interesting article, which is too long to reprint in its entirety. It is a good illustration of the amazing advance in understanding the behavior of radioactive substances which has resulted from nucleonics research. In addition, the technique of using ion exchange columns for separation of the rare earths provides a neat solution to one of the most baffling puzzles of analytical chemistry. EDITOR'S NOTE.**

Safer Phosphorus

➤ GREATER SAFETY in one of today's pre-atomic industries will result from a new phosphorus conversion method described recently by three TVA chemists, Phillip Miller, R. A. Wilson and J. R. Tusson, of Wilson Dam, Ala. They have developed a new and better way of turning white phosphorus, which is dangerous to handle, into red phosphorus, which is safe.

White phosphorus is melted. Then a blast of hot gas evaporates the unconverted part (which is recaptured), leaving highly purified, safe red phosphorus.

Patents on Chemical Processes

For twenty-five cents each you may obtain complete specifications of any patent from the U. S. Commissioner of Patents, Washington 25, D. C. Order by number and enclose currency or money order, but not stamps. Coupons for the purchase of patents may be obtained in quantity from the commissioner, at the same rate.

Sulfur From Ores

➤ SULFUR, that daemonic element that takes part directly or indirectly in practically every modern industrial operation, is extracted from certain types of its ores by a new process on which U.S. patent 2,429,477 has been issued to Arthur B. Menefee of Cumberstone, Md., and Herbert H. Greger of Washington, D. C.

The process, which is conducted at a temperature above the melting-point of sulfur, consists essentially in adding a liquid which will not wet the sulfur but which will wet the gangue, or stony mineral part of the ore, and cause it to form little lumps or pellets from which the liquid sulfur will then drain. Sulfuric acid of 98% concentration is the preferred liquid, but phosphoric acid, calcium chloride or other common chemicals may be used. A very pure grade of sulfur, free of objectionable coloring matter, is produced by this process, the inventors claim.

Mass Use of Electrons

➤ INDUSTRIAL USE of projected streams of electrons, hitherto confined to small-scale laboratory experiments, is proposed by Arno A. Brasch of New York, in patent 2,429,217. His design calls for an extremely large discharge tube that will pour a veritable torrent of electrons onto substances placed in its path, effecting radical chemical changes not achievable by other methods.

Special Glass

➤ A SPECIAL GLASS for the lead-in-tubes of electric lamps, vacuum tubes and similar purposes is covered by patent 2,429,432, granted to J. E. Stanworth of Sheffield, England, and assigned to the General Electric Company. It contains no lead, but added to the silica are boric oxide, the oxides of zinc and of calcium and related metals, plus up to one-half per cent of fluorine.

Gas From Paper-Mill Waste

➤ PAPER MILLS may hereafter get gas fuel for their boilers, and perhaps even some to spare for nearby towns, from the noisome sulfite wastes that have made them unwelcome neighbors in many communities because of their heavy contribution to the ruination of fishing streams. A process, on which U. S. patent 2,429,589 has been issued to Averill J. Wiley of Appleton, Wis., promises to remove the curse.

Pulp-mill wastes are among the worst of stream polluents because the fermentable substances they contain, mostly carbohydrates and related compounds, promote biological processes that exhaust the oxygen in the water,

thereby causing the death of all the fish. Getting these dissolved and suspended solids out before discharging the watery wastes has proved an expensive and unprofitable task.

Mr. Wiley's process puts these wastes through a series of tanks, in which anaerobic (airless) fermentation by certain bacterial strains converts them into the combustible gas methane. An explosive menace when it occurs "wild" in mines, methane has considerable value as a fuel.

It is sometimes necessary to provide the methane-fermenting organisms with nitrogen in the form of ammonium salts or urea, but for the rest they feed on the carbon-containing compounds normally occurring in the waste sulfite liquor.

New Rubber With Fluorine

➤ A NEW SYNTHETIC rubber belonging to the neoprene family but with fluorine substituted for the customary chlorine has been patented by a du Pont chemist, Dr. Walter E. Mochel of Wilmington, Del. Its basis is thus fluoroprene instead of chloroprene. Higher resistance to the solvent action of oils, and retention of its stretch and bounce at very low temperatures are advantages claimed for the new compound.

More specifically, the new rubber is described as a copolymer of 80% to 97% of 2-fluoro-1,3-butadiene with the balance consisting of acrylonitrile. It is molded, vulcanized and otherwise processed very much as other synthetic rubbers are.

Dr. Mochel has assigned his patent, No. 2,429,838, to his employing corporation.

Vacuum Furnace for Mg

➤ HIGH-PURITY magnesium can be obtained from magnesium oxide in the electrically heated vacuum furnace on which Hugh S. Cooper of Cleveland has been granted patent 2,429,668. The magnesium ore is mingled with calcium silicide, which serves as a reducing flux. Heated to the metal's evaporation point after air has been pumped out, the mass gives off magnesium vapor, which is condensed into solid form on contact with a water-filled vessel suspended within the top of the furnace. Patent rights are assigned to Acme Aluminum Alloys, Inc.

Tantalum Separation

➤ TANTALUM, a metal added to certain alloys, and especially favored for plates and pins for use in surgical bone mending, is separated from a mixed ore containing also another little-known element, niobium, by a relatively simple process on which patent 2,429,671 has been granted to Francois Cuvelliez of Hoboken — only this Hoboken is a town near Antwerp, in Belgium. The essential step is the passing over the ore of a current of chlorine at a temperature above 1,000 degrees Centigrade. This converts the niobium into its chloride, which is carried off as a vapor, leaving the tantalum behind.

Improvement in Resin

➤ FOR AN IMPROVEMENT in synthesizing sulfur-formaldehyde resins, patent 2,429,859 has been given to Dr. J. F. Walker of Lewiston, N. Y., assignor to E. I. du Pont de Nemours and Company. Addition of an acidic material, he states, insures a good yield of a rubbery plastic.

Jelly on Addition of Water

➤ JELLY without fuss or muss is promised to the housewife in U. S

patent 2,429,660, issued to Alexander M. Zenzes of New York. In its finished form his preparation is a caked granular powder, which only requires the addition of water and flavoring, or of fruit juice instead. It doesn't even need to be boiled.

To prepare it, a thick sugar syrup is made up, and pectin added. Pectin is the stuff that makes jelly jell; it is prepared commercially from good but unmarketable fruit. After the pectin addition the syrup is re-concentrated; then tartaric acid or some other food acid is added.

As finally simmered down, the product consists of sugar crystals, each surrounded with a film containing sugar, pectin and food acid, plus about 10% of water. Its most convenient marketable form is as blocks or bricks, which need only to be dissolved in water and let stand a little while to make firm jelly.

Date Pollen Hormone

➤ SOMETHING having the same physiological effects as the female sex hormone has been discovered in the pollen of the date tree by two Egyptian scientists, Dr. Ali Hassan and Dr. M. Hassan Abou El Wafa of Fouad I University in Cairo.

An extract prepared from the pollen was injected into the laboratory rats. At the same time, ordinary female sex hormone was injected into another set of rats. Both sets responded with the same physiological reactions.

Although the substance has not yet been obtained in pure form for analysis, preliminary physical and chemical tests indicate that it is closely similar to sex hormone extracted from animal sources.

It is interesting to note that pollen, from which this female sex hormone has been extracted, is the male element in plant fertilization.

Polishes Silver While Coating

➤ SILVERWARE can now be both plated and polished while still in the electroplating bath where the silver coating is applied. It is a new process, discovered by a Westinghouse scientist. When taken from the bath the object plated has the luster that housewives demand; no buffing is needed to give the required polish.

It is an important discovery to all manufacturers of silver-plated objects besause it saves material and time.

In the new process, the objects to be plated are immersed in the usual silver cyanide bath and the negative current, that causes the deposit of silver, is sent through. This negative current, however, is interrupted by intermittent positive charges, and these cause the luster. The positive current, of about four times the amperage used to plate the metal, is applied for a few seconds, discontinued, and sent through several times again. Any silver removed by the positive current remains in the bath.

Featherweight Twins
Show Technical Progress

Al and Maggie

Reprinted from the Industrial Bulletin of Arthur D. Little, Inc.

➤ DEMAND for light metals has been booming and may lead them to new importance. Aluminum is overtaking copper as the leading non-ferrous metal, and magnesium is the basis of a substantial industry. Part of the current demand is due to the shortage of all metals, including steel, and may eventually disappear. Even so, use of light metals during this shortage is teaching fabricators how to employ them in peacetime products, just as the military need for aircraft and light air-borne and man-borne equipment has already multiplied fabricating facilities and skill. Rises in the price of competitive materials are also important; for prices of the once expensive light metals are stable or declining. Aluminum now costs 15c per ingot pound and magnesium 20.5c, compared with 31.5c for copper and 11c for zinc. Also favoring the lightweights is the long-term trend to "quality" metals, with special characteristics more important than primary cost.

Each of the light metals has special advantages, besides lightness, for particular types of applications. Magnesium is the easiest metal to machine at a maximum speed where extensive drilling is needed, while aluminum is remarkably resistant to corrosion, a quality utilized in window frames and many other applications.

Aluminum production slumped from a wartime high to 409,630 tons in 1946, less than that of zinc, copper, or iron. In terms of cubic feet produced, aluminum had top ranking among the non-ferrous metals. Current production is close to 600,000 tons a year, more than 90 per cent of the nation's present operating capacity.

Building construction is the chief consumer of aluminum, accounting for 18 per cent of the output of Aluminum Company of America, which owned 51 per cent of the private capacity at the end of 1946. The outstanding new construction use is corrugated sheet for farm and industrial roofing and siding. Other major building applications include beams and panels for prefabricated buildings, heating and ventilating ducts, metal awnings, and even nails. Use of aluminum for residential windows has increased greatly; before the war only 25,000 were made, but it is estimated that over 2,000,000 will be produced this year.

Aluminum is displacing a fair amount of copper for window screens and insulated electrical wiring. Aluminum wire has been well received, but it is not expected completely to replace copper wire, although the substantially increased price of copper and its alloys favors this development.

Transportation accounts for about 14 per cent of the aluminum con-

sumed. Planes continue to be built primarily of aluminum, and marine construction employs it increasingly for small boats, passenger and cargo ships. Manufacturers of trucks, trailers, and buses are using more aluminum, particularly in body construction, and also in wheels. In the passenger-car field, pistons, cylinder heads, and timing gears represent an expanding market. This year and next, at least twelve states will use aluminum licence plates. The railroads are also using more aluminum; a number of all-aluminum passenger trains and hopper cars are in service, and an experimental refrigerator car is attracting favorable attention.

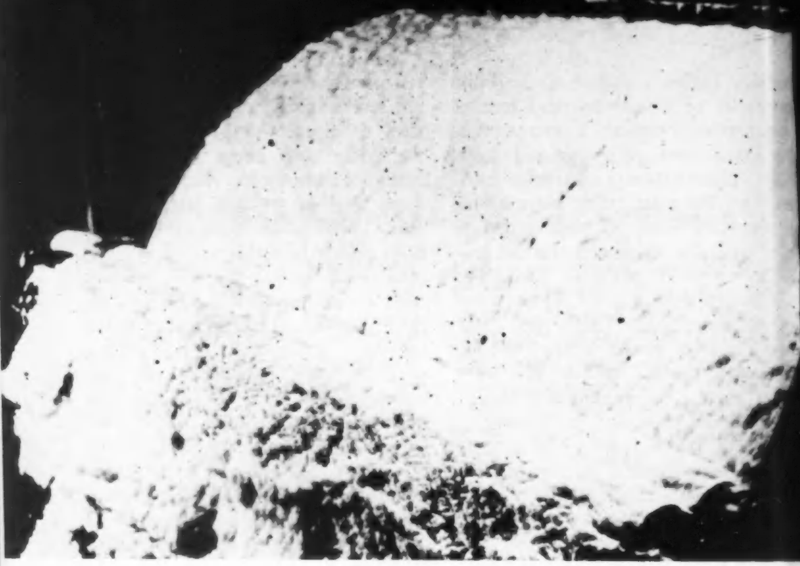
Magnesium is traveling fast, but is still far behind aluminum. Prewar consumption was only 3500 tons, but postwar consumption is estimated at 10,000 tons for 1947. The consumer item mass-produced in greatest numbers is probably the magnesium griddle, which one company turns out at the rate of 6000 a day. Here the excellent heat conductivity of magnesium provides a uniform temperature over the surface of the griddle.

Since magnesium is only two-thirds as heavy as aluminum and only one-fourth as heavy as steel, the price per foot is about the same as for aluminum, but twice that of steel. Such types of equipment as wheelbarrows, lawnmowers, and outdoor furniture are several pounds lighter than their steel or aluminum progenitors, but the added cost keeps them in the luxury class just now. Active development and larger-scale use will no doubt help to overcome the limitations and reduce the cost of magnesium products, just as was the case with aluminum. Much is being done to utilize the advantages of magnesium over other metals for various purposes, such as stiffness per unit weight, which keeps thin sheets from buckling. Special shapes may be extruded economically. One field where lightness outweighs cost is the manufacture of prosthetic devices, or artificial limbs. Skis made of magnesium are reported faster and sportier than wooden ones. One manufacturer states that a magnesium plate for the interior of a lightweight piano has a tonal quality superior to cast iron, and weighs 103 pounds less.

Time is on the side of the light metals, not only because it permits their further technical development, but because the sources of most other metals are becoming depleted, while sources of aluminum and magnesium are practically unlimited. Bauxite, the best source of aluminum, is abundant in all parts of the world, with large deposits in South America. And magnesium comes from the inexhaustible ocean.

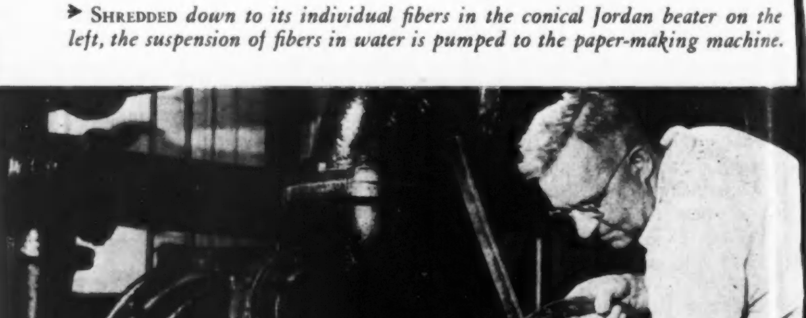
Emulsified whole eggs are normally dehydrated without loss of nutritional quality, but prolonged periods of storage even under favorable conditions result in marked loss of certain vitamins.

The death rate from accidents decreased in the United States in the past 30 years from 85.5 to 72.3 per 100,000 population; this is the period since the national safety movement began.



➤ Pulp *which may come from new fibers or from scrap paper, is digested with bleaching chemicals, then washed, to prepare it for paper-making.*

➤ Shredded *down to its individual fibers in the conical Jordan beater on the left, the suspension of fibers in water is pumped to the paper-making machine.*



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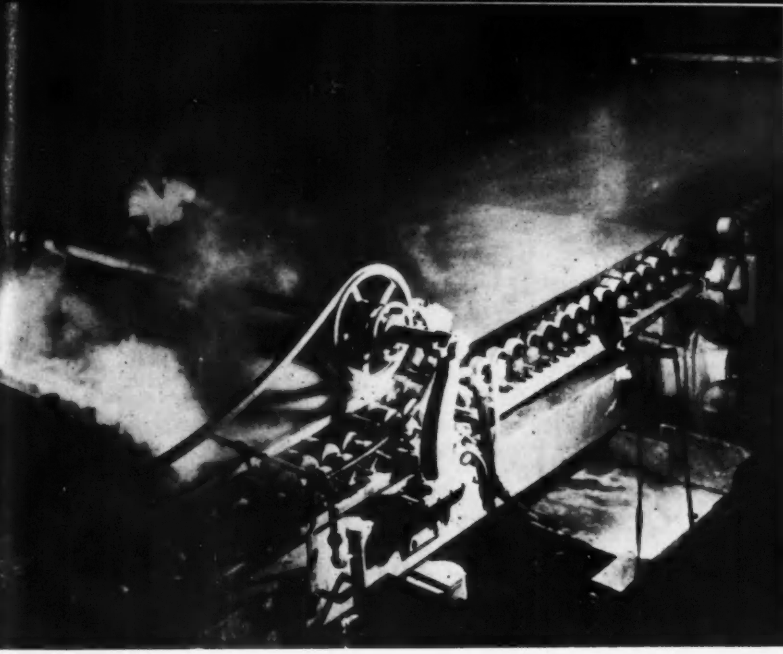

➤ FLOWING *out onto a blanket supported by a sheet of copper screen, water is first drained, then sucked, out of felted fibers as the sheet of paper is drawn continuously off the dry end of the Fourdrinier paper-making machine. At this mill of the Riegel Paper Corporation in Milford, New Jersey, from 1 to 3 per cent of Uformite, a urea-formaldehyde resin, is added to the pulp to give the paper greater wet strength.*

Paper Making a Mechanized Art

➤ FOUR STEPS in the process of making paper are shown in the accompanying pictures. First, the pulp is prepared; second, it is shredded to separate the individual fibers; third, the fibers suspended in water are flowed onto a supporting screen and felted together; fourth, the web of paper when strong enough to support its own weight is removed from the screen for further drying and finishing.

So the ancient Egyptians treated papyrus beside the river Nile. So, for the past hundred and fifty years, machines have made the process continuous, stretching out and rolling up the finished sheet as it rolls endlessly off the dry end of the Fourdrinier machine as more pulp is continually pumped onto the wet end.

Paper making calls on chemical processes especially in the first stage, to make satisfactory pulp out of wood,

cotton, or other plant material whose basis is the cellulose molecule. Caustic soda was the chief chemical used for preparing cotton and linen fibers for the "rag" paper of an earlier day. Sulfurous acid is used for digesting the wood from which most of today's white paper is made.

Traditionally hand-made paper was made sheet by sheet on an apparatus consisting of two frames, the mold and the deckle. The mold is a wooden frame covered with copper wire screening on which the fibers can be caught and felted together. The deckle is a similar frame held over the mold to keep the layer of fibers from floating away as the excess water drains off. Skill in shaking the fibers into a sheet of uniform thickness is gained by experience as it was among paper makers of earlier times.

For modern handicrafters who would like to master this ancient art, Science Service has assembled a paper-making kit which includes pulp and a number of samples of different kinds of paper, a mold and deckle for making antique laid sheets, with copper wire and felt blanket such as are used on actual paper-making machines. Detailed directions for making and experimenting with different kinds of white and colored papers are included in this FUNDAMENTALS OF SCIENCE *Papermaking Kit, which will be sent postpaid anywhere in the United States upon receipt of $4.95. Address: Science Service, Papermaking, 1719 N St. N.W., Washington 6, D.C.*

➤ FINALLY *strong enough to bear the tension of the rollers pulling it along, the sheet of paper comes off the paper-making machine and runs through a succession of drying and finishing rolls, winding up at the end on a core on which it is shipped. The product of this mill is glassine, a transparent or semi-transparent paper, some of it waxed, for wrapping candy, meat and many packaged products. Glassine also covers the peep-hole in the familiar window-envelope.*